System Dynamics Modelling and Decision Support (DIS1007)

Dept of Industrial Economics & Technology Management

Time & place: *Spring, 2002, starting 05. Feb, 10.15 Meeting room 9etg.SII.*

Course credits: *2.5 vt . Oral exam incl. presentation of project work (which is 50% of final grade)*

Main teacher: *Klaus-Ole Vogstad*

Academic responsible: *Nils Jacob Berland*

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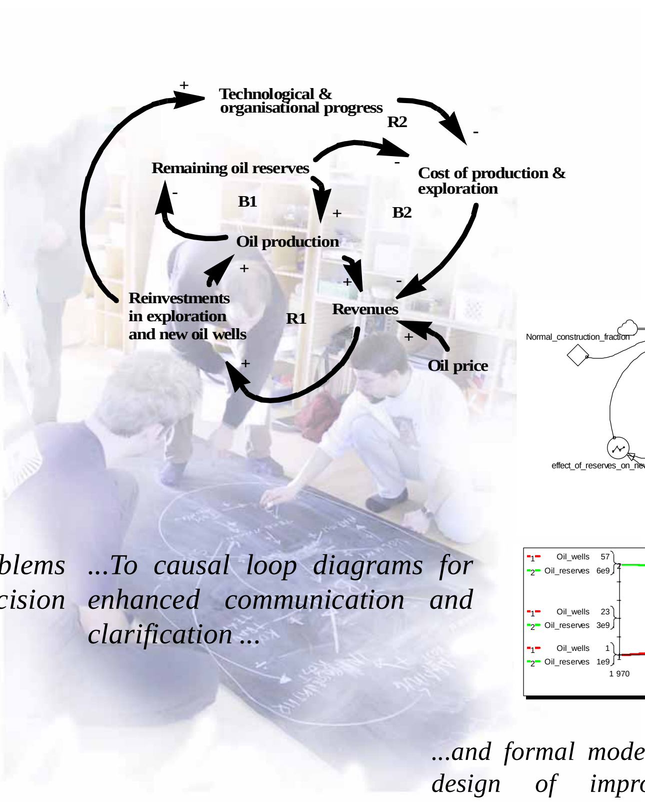
Origin

System Dynamics was developed during the 50ies by Jay W. Forrester at MIT. Originally developed to solve complex management problems within industry, it turned out to be a general method that could be applied in many areas, from industrial management problems to global environmental problems, urban planning, energy planning etc. The most famous studies are Limits to Growth, Urban Dynamics and Industrial Dynamics. The theory itself draws upon control-, organisation- and decision theory.

Mental model

Future development of Norwegian oil production.

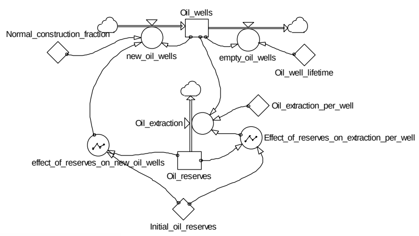
When Phillips struck oil in the North Sea in 1971, Norway started to explore the oil fields in the North Sea. Revenues from oil production were reinvested in new explorations and oil wells, increasing oil production and revenues that drive our fossil fuelled economy. In this process, new technologies, experience and organisational skills developed, improving production technology, reducing the costs of production and enabled us to dig even deeper into the fossil reservoirs. The remaining oil reserves are, however diminishing, but this effect is still being offset by the growth of investments and technology improvements of oil production and exploration. The figure below shows the yearly oil production in the North Sea. It seems that for the last four years, oil production has begun to peak. Authorities recently started to encourage the discovery of new oil resources to counter the anticipated decline in oil production over the next decade. Neither fluctuating oil prices in a volatile market nor new surprising discoveries can overshadow the long term trend of diminishing production due to resource scarcity and its effects on costs. When the costs of new exploration and production offset the revenue of production and technology improvements, oil production is bound to decline.

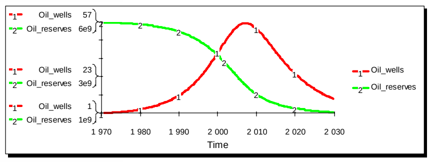


From discussion of complex problems among stakeholders and decision makers...

...To causal loop diagrams for enhanced communication and clarification ...

Formal model





...and formal modelling, simulation, synthesis, design of improvements and enhanced understanding.

Figure 1 From discussion of problems to formal modelling and synthesis

Method

The method is to transform mental models to formal models, as pictured in the figure below. Mental models are each individuals understanding of a problem and its causal relationships. The understanding is communicated through discussions, and in written text. Formal models, on the other hand, are mathematical models, explicitly stated as a set of equations, or in a diagram.Usually, technical, economical and social systems are treated separately in science and real world, though these systems are heavily interdependent and interacts with each other. The system's response to changes are non linear and often counter-intuitive and difficult to anticipate without the support of computer models. System dynamics enables us to treat problems involving both technical, economical and social factors within a common systems theory. Energy, material, capital, workers and information are viewed ad stocks and flows forming a noniron system with multiple feedbacks. The system dynamics method bridges the gap between different approaches in scientific disciplines and is therefore particularly suited for interdisciplinary problems.

Goals of the course

The course represent system dynamics with a minimum of mathematical formalism. The goal is to develop your intuition and conceptual understanding, without sacrificing the rigor of the scientific method. The course will provide the students with a theoretical basis in system dynamic modelling. Students will learn to formulate complex problems using causal loop diagrams and stock & flow diagrams and analyse these problems using system dynamics software. Basic elements of stock and flow diagrams include Stocks, flows, converters, feedback loops, time delays. Techniques for modelling include decisions, human behaviour and model testing. Scenario planning and Decisions under uncertainty.

(You do not need calculus or differential equations to understand the material - the models are constructed using stock & flow diagrams)

Weekly lectures on seminar form. Oral exam including presentation of project work (50%)

Course material

Business Dynamics, (John Sterman, 2000), selected chapters, plus material handed out during the course.

Supplementary literature: *The Fifth Discipline* (Peter Senge).

Software: Vensim or Powersim

Figure 2 **Preliminary course schedule. Chapters refer to "Business Dynamics" by John D. Sterman (2000). The selected parts of chapters will be specified later.**

week no.	Subject	Business Dynamics (chapter)
6	Introduction to system dynamics. Causal loop diagrams	5
7	CLD's continued + well-known SD models (LTG, Beer Game)	6
8	Stocks & Flows (roadmap 1,2,3) positive/negative feedback	6,8
9	S-shaped growth, multiple feedbacks	9
10	Time delays, material and information delays, non linear relationships	11, 13
11	Modelling Decisions and human behaviour	14, 15
12	Model testing	21
13	Easter	
14	(Still Easter holidays?)	
15	Scenario thinking	Fifth Discipline (NJB)
16	Decisions under uncertainty	Stein Wallace
17	Summary	
??	Oral exam & presentation of project work (Presentation at seminar. Documentation within Vensim/Powersim model)	