SYSTEM DYNAMICS MODELLING IN A CABLE MANUFACTURING CORPORATION

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ABSTRACT

The paper describes eight problems within the Cable Division of Standard Telefon og Kabelfabrik A/S which are currently being analyzed using system dynamics. Problem 7, concerned with information systems projects, is described in detail.

THE CORPORATION

STK (Standard Telefon og Kabelfabrik A/S) was established in 1915, with the primary goal of engaging itself in the transmission and distribution of electricity generated from Norway's many waterfalls. Through the manufacture and sale of cables and wires, the company helped in making it possible to carry large quantities of hydro-electric power from the many waterfalls to areas where it was mostly needed. This was STK's main activity for 15 years, but in 1930 the company merged with ITT and thereby acquired access to highly advanced technology, both in telecommunications and electronics.

STK is today one of Norway's leading industrial enterprises, with 7 factories spread throughout the country. The company enjoys international recognition in a number of product fields and is an undisputed world leader in high-voltage

submarine cables. The company's main products are power cables, telecommunication cables, telecommunication equipment, white and brown consumer goods, marine electronics and components.

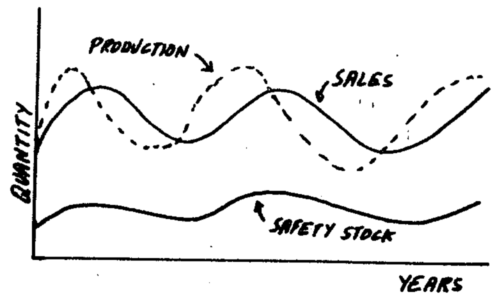
In the Cable Division, we have identified some problems that could benefit from system dynamics modelling for their solution.

PROBLEM 1: SAFETY STOCK

For some cable products, it has been decided to keep two weeks of sales in stock. If sales go up, then inventory has to go up. Hence, production has to increase more than sales to build up inventory. If sales drop again, then inventory has to be reduced. Hence, production has to decrease more than sales. This is obvious. But it is not acceptable. Management is facing bigger fluctations in production than in sales. It should, of course, be the opposite.

Is production planning overreacting to changes in sales? Is it necessary to permanently keep two weeks of sales in stock? Can the way sales forecasts are used be improved? Can some kind of information smoothing help solve the problem?

Fluctations in production and safety stock caused by fluctations in sales



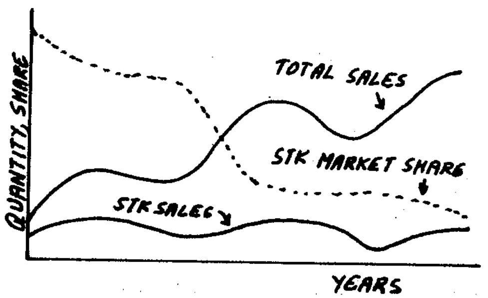
Discussions which arose from this reference mode lead to more emphasis on longer term consequences of production plans in the factory. The modelling process stopped at this reference mode after having developed a small DYNAMO-program, since a mathematical formulation was not expected to generate new insights.

PROBLEM 2: MARKET SHARE

STK's market share for some cable products has declined in recent years. Strangely enough it seems that market share decline took place during years of growth. This growth was of such magnitude that STK's sales, despite declining market share, increased. In periods of stagnation and decline, however, it seems that STK kept its market share.

Did the company lose market share because of capacity constraints? Are sales budget figures aimed at and achieved, although more could have been sold? Are product prices changed to hit planned activity levels? Can markets that are lost during good times be regained during bad times?

Sales fluctuations, but growing trend causing decline in STK market share

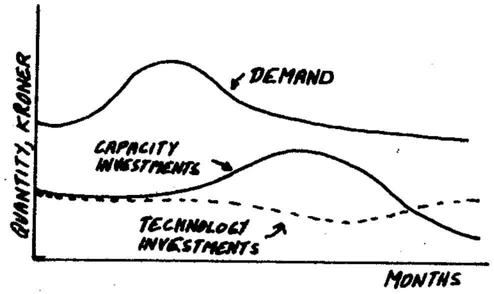


The marketing people found this hypothesis interesting. Statistical material to check this reference mode would, however, be too time consuming to find. The modelling process was stopped.

PROBLEM 3: TECHNOLOGICAL INNOVATION AS AN ALLOCATION PROBLEM

Resources allocated to technological innovation can be spent on other activities, such as capacity expansion and marketing. Hence, competing needs for corporate resources may cause over- or under-allocation of resources to technological innovation. The allocation cannot be based on simple financial formulas, such as payback-time, because of interdependencies between alternative investments. A corporate model to study allocation strategies is needed. As an example, the following reference mode shows possible response to a short-term increase in demand.

Allocation responding to a short-term increase in demand

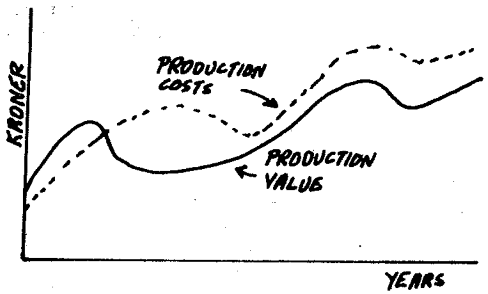


This problem definition was viewed as interesting. To get down to specific quantifiable elements was judged to be too much work to continue the modelling process.

PROBLEM 4: PRODUCTION-ACTIVITY AND -COSTS

Sometimes production is cut back. Then costs that vary proportionally with production drop. But most costs do not drop. Action must be taken to cut back on these costs. Such action takes time. Opposite, when production increases, only a few costs will follow. It takes time before the other costs follow. How can these costs be prevented from following?

Delayed cost response

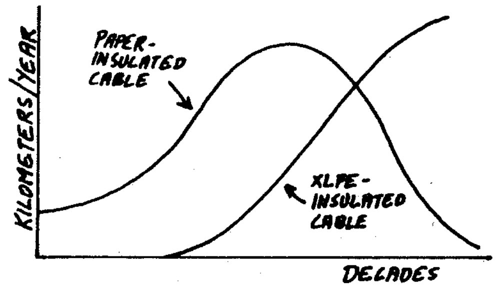


An analyses of the cost components showed that some components are more reactive to changes in activity than others. Those components are already focused by the comptroller, so the modelling process stopped after having developed a model that dit not work.

PROBLEM 5: PRODUCT LIFE CYCLES

Paper-insulated power cables are on their way out, and XLPE-insulated cables are taking over. Telecommunication cables with metal cores are on their way out, and fibre optical cables are taking over. How long do the products last? When should preparations for new products start?

From paper to cross-linked polyethylen (XLPE)

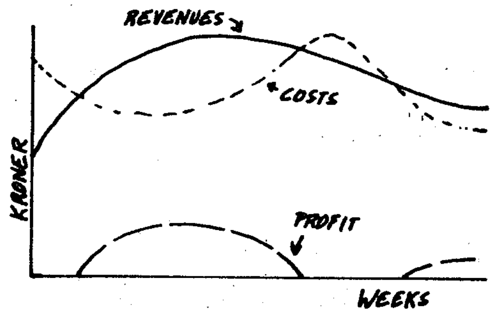


This kind of issue is adressed by top management. We did not want to involve them in the early phases of internal system dynamics modelling, so we dropped it for the time being.

PROBLEM 6: BUDGET PROCESS

Each fall, a budget for the coming year is produced. The budget process lasts for three months. Initial budget figures may show high costs and low revenues, resulting in expected loss next year. During the budget process, new potential revenue sources are sought and identified, while cutbacks in costs are planned.

Expected revenues and costs changing during the budget process

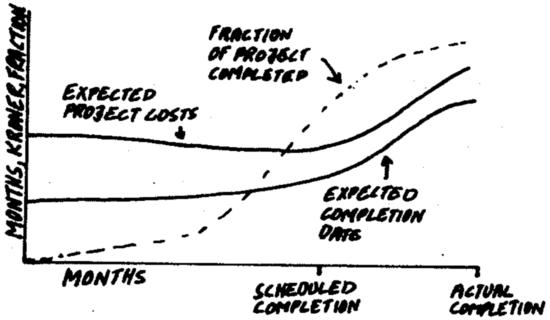


The comptroller's department was sceptical to this approach to an analysis of the budget work. Other departments, however, stated that this was what happened in the process almost every year. Both the comptroller's department and other departments stated the opinion that the process was useful in clearifying budget assumptions about expectations and plans. The work involved in the budget process was agreed to require too many cycles, though, so the number of cycles will be reduced.

PROBLEM 7: INFORMATION SYSTEMS PROJECTS

To develop a computer-based information system takes time and money. Often both time and cost estimates are considerably overrun before the project is finished. All kinds of special events in the project are blamed to have caused the problems. Since this pattern repeats itself in almost every project, there might be some generic structure in every information systems project causing delays and cost overruns.

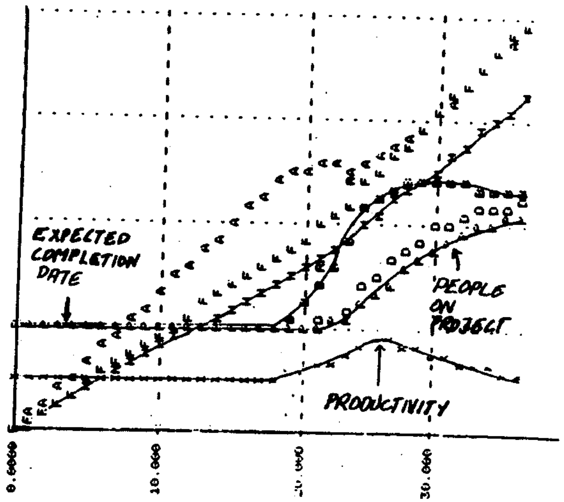
Project late and costly



This reference mode reminded us of an article by Edward B. Roberts about "A Simple Model of R&D Project Dynamics" in his book "Managerial Applications of System Dynamics" (MIT

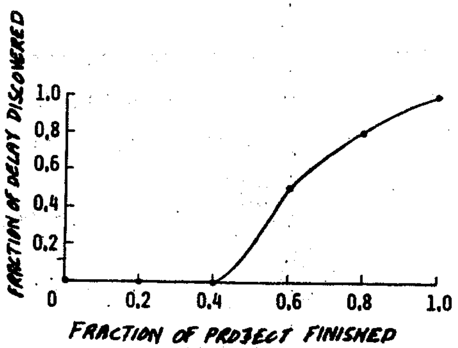
227 Press 1978). We studied his model carefully, developed a similar causal loop diagram, flow diagram, parameter estimates and DYNAMO-program. Key feedback loops include forces that influence project productivity and the number of people on the project, like pressure from being late.

Base simulation of the model



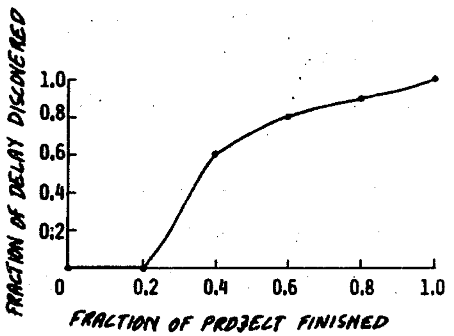
The base simulation is a.o. based on the assumption that deviations from project plan are first discovered after fourty percent of the project has been completed.

Table function in base simulation



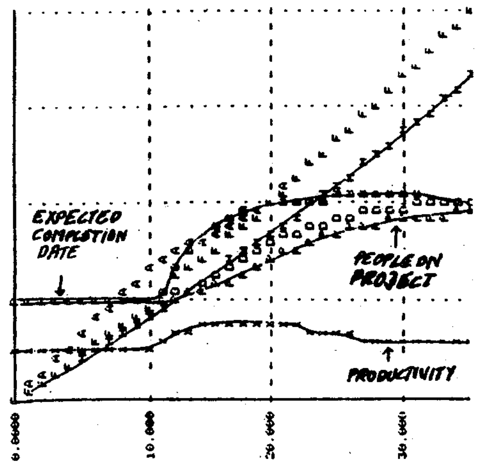
In our first rerun we tested the consequences of being more aware of possible project delays.

Table function in rerun



The following simulation shows that the curve for expected completion date starts to rise earlier in the project. The curve does not rise as steep as in the base simulation. This is because the project is in an earlier stage, so the hidden work is less and there is more time remaining to do the hidden work.

Rerun: delay discovered earlier

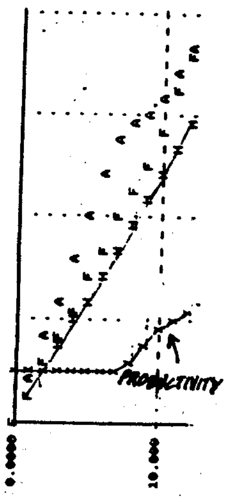


This simulation turns out an earlier completion date, but higher costs measured in total number of man-months. The reason for more man-months is that the pressure on productivity from being late is reduced by employing more people on the project and by updating planned completion date.

Other simulation reruns have been performed with the model, generating substantial insights into the dynamics of information systems projects.

A key assumption in the model is that a project starts with an expected completion date based on the number of people to work on the project, their planned productivity and, of course, project size. If management wants a project to finish earlier or later, they have to put more or less people on the project, put more skilled people on the project or reduce project scope. If management wants a quick project, say in 1/3 of the originally estimated time, but no reduction in project size or increase in skill level, then internal dynamics of the model generate the following simulation.

Project to finish in 1/3 of the originally planned time



A similar simulation assuming that 2/3 would be desired, was performed. The following table compares results from base simulation (30 months), simulation assuming 2/3 (20 months) and 1/3 (10 months).

	DESIRED PROJECT DURATION (MONTHS)	ACTUAL PROJECT DURATION (MONTHS)	TOTAL MAN-MONTHS	PEOPLE ON PROJECT (PERSONS)
Base simulation	30	36	811	31
Simulation 2/3	20	25	779	44
Simulation 1/3	10	13	738	70

Management finds it desirable to have as short projects possible, requiring as few man-months as possible. On the er hand, management finds it hard to make many people .ilable to work on the project. Management is facing multi .teria decision making.

Methodology to guide this decision making exists, involv- j structuring of objectives, utility theory and preferences ler uncertainty. This methodology is included in a Norwegian ttbook on system dynamics by Petter Gottschalk and Fred nstøp with the title "Kvantativ beslutningsanalyse for ledere planleggere" (Universitetsforlaget 1983).

Using this methodology to choose between the three tions, guides management through a process of determining ructure of objectives, utility functions for project dura- on, total man-months and people on project, and preferences ider uncertainty. Based on results from this process and inagement attitudes, management will decide to go for a very iick (10 months), quick (20 months) or normal (30 months) :oject. The utilities and preferences will vary from project) project, thereby leading to decisions to sometimes run slow cojects and sometimes run quick projects. In our case example, ie project was so important to finish quickly that it was ecided to plan for only 10 months project duration.

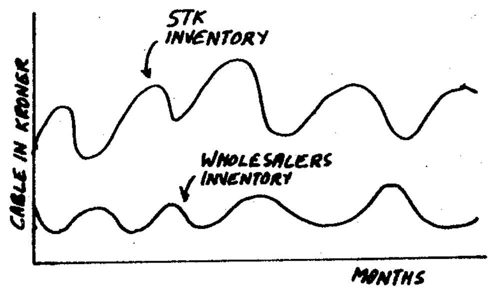
The combined methodology of using system dynamics and ultiple criteria decision analysis has proven quite useful, nd we will continue improving this model to help plan future nformation systems projects.

PROBLEM 8: ONLINE ORDERING BY WHOLESALERS

Cable wholesalers place their orders with STK by phone or by letter. The order department in STK processes these orders by using terminals to an online finished goods computer system. The computer system gives information about inventory availability of cables and cable production plans. Based on this information, the ordering department can tell customers when STK is able to deliver. The customer may respond by ordering more or less or not at all. To speed up this ordering process, wholesalers may be given access to STK's online finished goods computer system to check cable availability and place their final orders. Giving wholesalers this possibility might lead to a closer and more extensive cooperation between the wholesalers and STK.

But there are also some threats involved in doing it. For example, if STK has little left in stock, then wholesalers may order a lot to be sure to get enough. Opposite, if STK has much cable left in stock, wholesalers may order little because they know STK has sufficient to supply them on short notice. This behaviour pattern may lead to fluctuations in ordering and inventories, which can harm both STK and wholesalers. Both will have to keep substantial inventories to protect themself.

Shifting inventory levels



Two models were developed to study this problem. The first model focused on long-term (years) development, the second on short-term (days) ordering responses. Several DYNAMO-simulations where performed with both models, showing extreme sensitivity to a few parameter values. STK's marketing department is now in the process of evaluating both models by looking into sensitive parameters and different simulation runs.

REFERENCES

1. Edward B. Roberts, Managerial Applications of System Dynamics, MIT Press 1978.

2. Petter Gottschalk and Fred Wenstøp, Kvantativ beslutningsanalyse for ledere og planleggere, Universitetsforlaget 1983.