

Nice boat! But what's the upkeep like?

A new concept for those who depend on capital-intensive assets



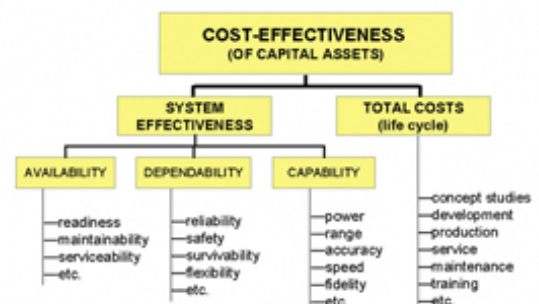
Arno Schrauwers

How do I get the best value for money? This is a question that has been on practically every person's mind at one time or another, but finding the answer is not so simple for large technical systems, and is becoming increasingly difficult as the technical complexity of such systems increases. The purchase price of a frigate, an aircraft, or railway line is more or less known, but what is the price of capital assets like these during their lifecycle, and to what extent will they satisfy the requirements of the purchaser? Navy man Ir. John Stavenuiter has tried to provide an answer to these increasingly pressing questions with his amico modelling tool. He has tested his model on the real-life experiences of a real navy ship, HMS Rotterdam, a troopship of the Royal Dutch Navy. Stavenuiter appears to be the first person to define an integral, digital modelling tool to handle lifecycle management. amico can be used to 'supervise' ships, trains, and infrastructures, but also other complex systems, such as wind farms.

Over the past twelve months, there has been a lot of

Hr. Ms. Rotterdam, the Royal Netherlands Navy's troopship. The ship's sensor, weapon, and communication system (sewaco) served as the model for the first test with amico, a management system for capital-intensive assets. The lifecycle costs of the ship have been estimated at approximately 300 million euro, with the sewaco system accounting for half of that.

Cost-effectiveness structure according to Juran



heated discussion about the proposed purchase of a successor to the Royal Dutch Air Force's F-16 jet fighters. For the time being, the American aircraft-to-be, the Joint Strike Fighter, has won the fight. What its initial cost will ultimately be remains unclear, and that is forgetting the additional costs involved in keeping the aircraft operational during its lifecycle. The amount of money that is going to take will be even less easy to define. Lifecycle costs cannot be disregarded, far from it; they can easily amount to several times the purchase price.

The Dutch department of public works builds lots of roads, bridges and tunnels. A budget is made available for the construction of each road, but strangely enough, the department cannot tell offhand how much a certain road has cost. The figures can be supplied, but unearthing them from the sea of data would take a team of employees several days. Small wonder, one is all too easily persuaded to think, that budget overruns for large investments are the rule rather than the exception (and we haven't even touched on the subject of fraud, which is probably made easy in part by this lack of budgetary control).

To begin at the beginning. Suppose Admiral Ironclad (a fictive character) wants the Royal Dutch Navy to invest in an aircraft carrier. In public service terms the question would be, how does one get the best possible return from such a huge investment, taking into account the operational requirements?

'You start by quantifying the requirement. If there is no requirement, you don't have a problem', says maritime engineer John Stavenuiter, head of engineering at the SeWaCo (sensors, weapons, and communication systems) division of the Royal Dutch Navy. He was recently awarded his doctorate at Delft University with a thesis on this subject.

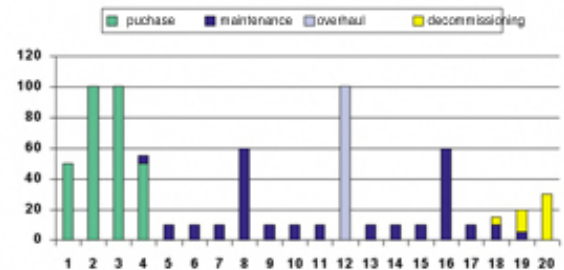
'I started my research by making a survey of existing, accepted methods for defining these requirements, and using these methods as a basis for a functional and technical design. This is in fact a systems approach, which is why I had systems developer Henk Sol, another professor from Delft, as supervisor besides Prof. Sjoerd Hengst of the Maritime Engineering faculty.'

New approach

The survey yielded 41 useful methods, each of which was assessed by Stavenuiter. He finally subjected twelve of these to a thorough analysis. They included such well-known methods as Life Cycle Analysis (LCA), Product Data Management (PDM), Human Resource Management (HRM), and Total Quality Control (TQM). From these methods, he distilled a new approach of which the end result was the amico model (Amico stands for Asset Management Information & Communication).

Before he could start designing his model, Stavenuiter had quite a bit of spadework to do. 'I took a look at how various different organisations tackled this kind of problem. I visited organisations such as the U.S. Navy, NedLloyd, KLM and the Dutch railways. Through nvdo, the Dutch Association for Effective Maintenance, I interviewed 200 companies. The results were a bit

Large enterprises such as oil companies, with vast capital-intensive installations, find it very difficult to determine the cost-effectiveness of their equipment. Government organisations like the Royal Dutch Navy also feel the need for an instrument that can show the financial pros and cons of different investments since the taxpayer's money can only be spent once. A number of models are available to find out about the effectiveness of expenditure, the one invented by the American, Joseph M. Juran, being very popular. His model divides a system's effectiveness into the parameters of availability, dependability, and capability, each of which is then further subdivided. In this case, the expenses have been specified per cost type.



In addition to an insight into the various cost types, lifecycle cost control requires knowledge of the lifecycle periods in which each of the expenditures has been planned.

Logistics Process Cycle (LPC)



To establish a relationship between costs and system effectiveness, Stavenuiter has subdivided the equipment logistics process into eight process steps. Each step has to be in balance with the preceding and subsequent steps in the cycle.

thin. Most of them had a general idea what it was all about, but none of them had ever taken any action concerning real implementation. So I went and visited 22 companies to interview the logistic managers and engineers involved.'

Stavenuiter then tried to find the main factors defining the success of asset management. He arrived at nine critical factors. On the basis of these he started building a system, the amico mentioned earlier, which contains the entire process, from requirement definition to decommissioning. A bit like who does what when, and how to get from A to Z. Stavenuiter prepared the mathematical model, and the research organization tno turned it into a program that can be used on an intranet or the Internet so anyone at any time can get an update of how the system under review is doing, down to the smallest detail, including the cost (estimated as well as actual) and the extent to which it satisfies the requirements.

'The model gives all the relevant inputs into the on-going state of affairs. The current practice in the Royal Dutch Navy, as elsewhere, is that the Admiralty has a certain requirement, so they go to the government to try to get the funding, or more funding. Engineers tend to regard the question of funding as no more than an obstacle preventing them from fully realising their brilliant plans. I try to explain to the people involved that even engineers will have fun trying to maximise the return on a certain investment in a high-tech system, since that is what navy people are always discussing. Professor Hengst is one of the few naval engineers to take the importance of cost into account.'

amico was tried out on the troopship HMS Rotterdam.

Dr. Stavenuiter sits at the computer and conjures up some diagrams on the screen that look a bit like a flow diagram. They are used for, among other things, representing the relationships between various parts, as well as the current status of any part of Rotterdam's inventory, which includes two very expensive Goalkeeper guns (installed at a cost of more than 40 million euros). He clicks on a symbol for one of the aerials. A window pops up showing, among other data, the cost, both estimated and actual, of the aerial, together with a comment field. There appear to be problems with rainwater leaking in.

You can see a ship's number of operational days, and how they relate to the planned revision date, as well as what an extension of the maintenance period will mean to the system's operational availability, and which know-how — and consequently, which training — is required. The short demonstration by Stavenuiter is enough to make clear that amico doesn't miss a beat where the ship is concerned.

And there is more, according to Stavenuiter: 'You can list reports on many different queries to show expenses, complaints, actions, planned or not, etc.'

Input

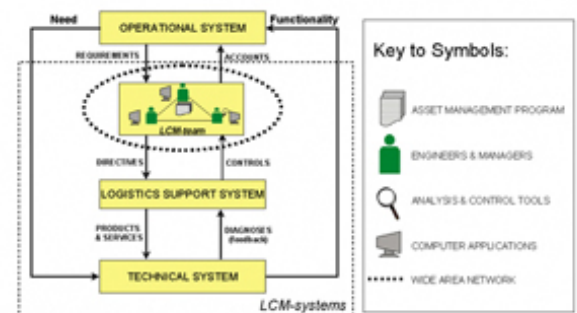
The basis for a system model like this is a regular update of all the data it covers. A link has been created to the Royal Dutch Navy's data collection system,

The Logistics Process (Life) Cycles



To be able to manage the asset throughout its lifecycle, the process cycle must be kept in constant balance. For a ship, the circle starts at the design office, and ends at the breaker's yard. As a prerequisite, the process steps must be continuously adapted to the ship's lifecycle (about 30 years).

Conceptual LCM-systems Model



Using a system approach as his basis, Stavenuiter developed a model to control the cost effectiveness throughout the life cycle of a ship or any other capital asset. He distinguishes four subsystems. They are the operational system (which includes the owner and user), the management system, and the logistic system (which consists of operational processes and the technical system — the ship itself). The management system plays a crucial role in the model, since it converts the requirements into directives, and controls the results. Based on these results, the responsibility is transferred to the requirement source (the customer or user). To enable the management to purchase (or build) the right equipment at the lowest cost, and to control its performance and cost during use, the following are essential: a capital assets management program based on a lifecycle analysis, in which all the functions, installations, as well as the actions required to acquire and maintain them, have been specified; technical staff and expert managers who can be held responsible for obtaining the right results; adequate analysis and control tools to report the results and if necessary, take corrective action; sufficient information processing capacity in the shape of computer power; open and direct communication facilities in the form of an intranet or the Internet.

which continuously refreshes the data. For land use, the system runs on servers that provides the parties involved and other user access through an intranet or the Internet. Depending on authorisation, a user can then enter or change data, or simply browse the available information. With the ship at sea, the data are loaded into an onboard server. This means they cannot be kept fully up to date, but even that can be accomplished using an Internet link via satellite.

It all looks rather impressive, even though Stavenuiter says that his system model is based on elementary maths (the complexity is in its size). Nevertheless, to set up a similar system model for, say, a cat cracker, must take endless hours of preparation and data entry work. Stavenuiter thinks the work need not be prohibitive. 'Collecting the necessary information is probably going to take most of the effort. A handful of people would probably need no more than a month or two to set up quite a useful model.'

He uses a diagram from his thesis to illustrate his point. 'This is what it is all about. We have an operational system, an LCM team (LCM stands for Life Cycle Management), logistics support, and a technical system, in which the LCM team is supported by people, the computer program, analysis and control tools, and a computer network. In fact, this model can be used to manage any complex technical system.'

As a result of his research, Stavenuiter now advocates replacing current practice among Navy organisations and elsewhere of setting up separate design, user, maintenance, etc. teams (depending on the point of progress within the overall cycle) with a single LCM team, the only change involving a shift in focus as the cycle progresses (and including the preliminary stages). 'Look, this is the LCM model. Now that isn't too difficult, is it?'

Worldwide

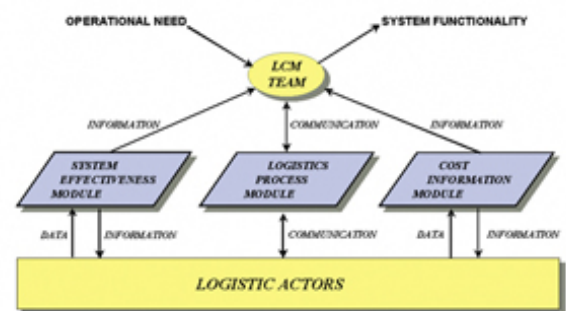
End of show, curtain. Isn't that the way it goes with most research work? Of course, Stavenuiter hopes that a different lot will befall his efforts.

'We hope to implement the system for the Royal Dutch Navy's proposed purchase of new LCF air defence and command support frigates, and we will try to market amico through scientific channels as well as in industrial and consultancy contexts. I propose to present the system as a new concept for organisations that depend on capital-intensive assets. For this purpose I have set up a foundation to keep those activities separate from my Navy work. The foundation is currently in contact with a petrochemical company, the Dutch railways, and offshore industries, and we are supporting ecn, the Dutch Energy Research Centre, for a proposed offshore wind farm.'

Are we talking about a marketable product, and if so, who can claim proprietary rights? Stavenuiter: 'I have the copyright, but if anyone else uses the basic idea to write a new computer program, I can't stop them.'

Could the system have been used to take a better-informed decision about the proposed F-16 successor, and would it too have offered the JSF as the best option?

CONCEPTUAL LCM MODEL



To realise the adequate analysis and control tools, a computer program was developed that can be used to model the capital asset itself – the ship – and all the activities required throughout its lifecycle. The program comprises three modules. The System Effectiveness Module is used to model the technical system; the Logistics Process Module is used to map and correlate the various activities, and the Cost Information Module is used to collect every cost item and specify it according to cost carrier and cost type. The entire model has been set up to make it suitable for general use, i.e. not just for navy ships, but also for the offshore and petrochemical industries, or the Department of Public Works.



Managers of other capital assets, e.g. bridges and roads, also feel an increasing need to obtain a clear insight into cost effectiveness and those responsible for it. The resulting system functionality is expressed in operational functions such as traffic connections, lighting, and safety. The functions are realised by means of technical installations: e.g. supporting structure, road surface, lamp posts, security unit, etc.. Many activities, and consequently, workers and management, are required to draw up the system's specifications, find funding, decide on manufacturers, supervise construction, manage maintenance, and – after decommissioning – ensure that demolition takes place according to regulations. In this way, the modelling system can be used to model any capital asset and its life time support.

‘Of course, that is something I did not consider, but it could be done. The first step is to improve risk control. The Royal Dutch Navy had been planning to order a mine hunter that could also be used in wartime to sweep mines. However, the two capabilities could not be combined in a single polyester ship of just 50 metres length. In the end, the plans were shelved, but it was touch and go. Another large Dutch project, the Betuwe rail link, has probably progressed too far by now to cancel it. This system highlights the bottlenecks, so you can see at a glance where the problems are. And this may well prove to be one of its shortcomings, according to Stavenuiter, since the LCM model pinpoints exactly who went wrong at what point. This can rankle, with psychology playing a role.

‘Three years ago the Navy maintenance department hired an extra 20 university and polytechnic graduates to provide support for the logistics of the LCF class. Two years later my boss asked why there weren’t any visible results so far. The new approach brings to light a whole raft of problems.’

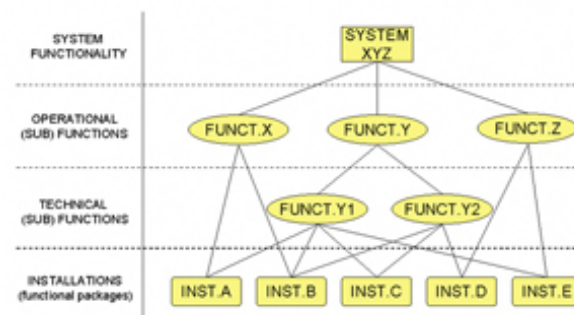
Would things have been different otherwise?

‘There is no way to tell for certain, but I think that the idea of spotting the problems early on in the proceedings has received great support as a result of the insight provided by this model.’

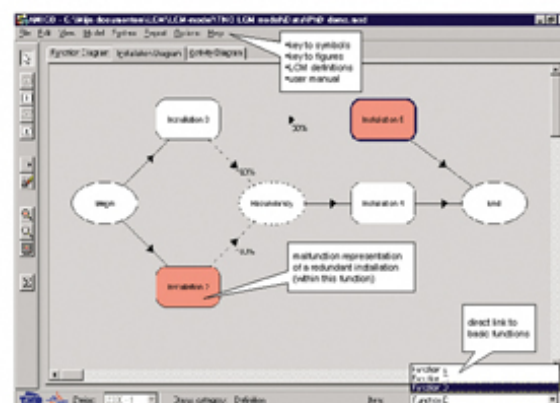
After all, Stavenuiter has postulated the thesis that ‘implementation without insight into the system leads to exploitation without any outlook on the desired result.’ Whatever the case, one result is that supervisor Hengst can look forward to an extended collaboration with the Navy. n

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Functional material part breakdown

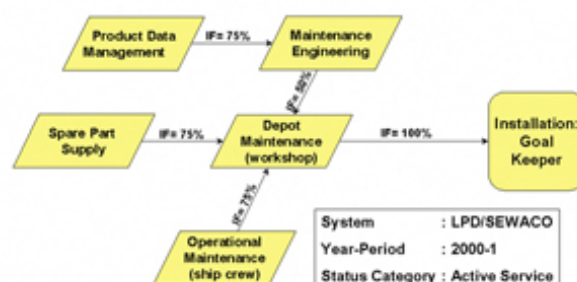


The functional design is based on a number of predefined steps. To begin with, the operational functions are defined. These are functions the principal/user wishes to pay for, e.g. transport and safety. These functions are then logically subdivided until the final so-called technical base functions, are reached. These are the functions that have an unambiguous relationship with one or more installations such as blocking a road or bridge has with barriers, electronic traffic signs, and traffic lights.



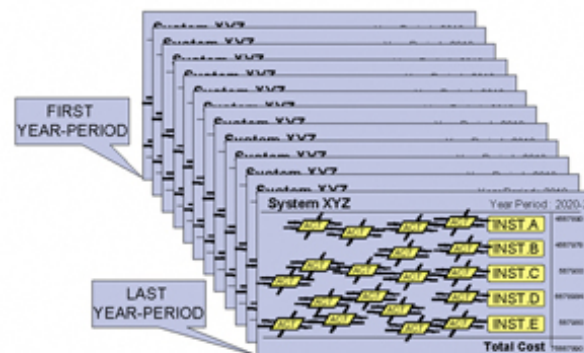
To provide insight into the relationships between installations and their order of precedence, a functional block diagram is prepared for each base function. This is used, in combination with the Function Diagram, to enter the entire capital asset into a model, which can then be used to perform calculations that will provide insight into the effects of insufficiently reliable installations at a higher level, both performance-wise and cost-wise. For example, the incorrect operation of barriers on a movable bridge affects the performance of the entire system, because the bridge cannot be operated safely without them, which will result in higher costs, even discounting the fact that the barriers themselves will cost more as a result of repairs, or even modifications, to remedy unforeseen malfunctions.

The Goal Keeper Activity Diagram



The Royal Dutch Navy has applied Stavenuiter's LCM model to the HMS Rotterdam. The ship carries 2 automatic rapid-firing guns that provide a last-ditch defence against incoming missiles. The requirements regarding the performance, reliability, and operational availability of these guns are extreme. In addition, they are among the ship's most expensive pieces of equipment. The navy, and the ship's complement in particular, have a need to know at any time who does what when, and why. AMICO fills this need by modelling the required operational processes for each installation and for each period. Even more important is the need for communicating this information to all those involved in order to be able to pinpoint the source of the problem in the event of a malfunction and to decide which of the parties involved (workshop, maintenance engineer, configuration manager, magazine) may require additional support to solve the problem in the shortest possible time.

Logistics Process Program



Finally, the Logistics Process Program is constructed by linking together the various models for each phase of the lifecycle. This effectively creates a filing cabinet in which every period of the lifecycle is defined, including design, construction, commissioning, operational period, support, maintenance, and finally, at the end of the lifecycle, decommissioning. For the future these are plans, for the past they are reports in which the current results are compared with the planned results. It is a bit like comparing a company's annual reports.

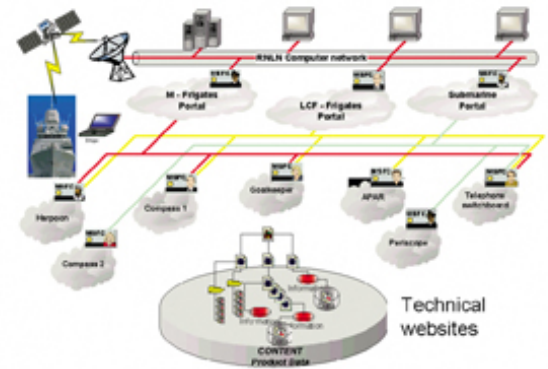
	Baseline	Actual	What if (calculated)	What if (override)
Installation Performance	100	75	105	(%)
Total Cost	300000	300614	400000	(Euro)
Cost Effectiveness	100	75	95	(%)
Fixed Cost	300000	300000	300000	(Euro)
Variable Cost	50000	614	614	300000 (Euro)
Active time	120	220	220	(Days)
Reliability	90	75	75	(%)
Capacity	95	100	100	(%)
Availability	90	46	46	(%)

Comments:
 Maintenance Engineer Satcom 19-10-00:
 The satcom installation shows construction failures, which have a negative impact on the reliability. The overall performance does not meet the requirements. Several COP's and modifications are initiated. It is expected that these actions will improve the reliability considerably.
 Systems Engineer, 22-12-00: a what-if analysis performed with respect to the modifications, for full report see satcom-web001.

Since the entire system modeller is digital in nature, and easily accessible though the Internet or an intranet, the model can be browsed at system level (e.g. a ship's commanding officer, or a general manager) down to activity level (first-line management, i.e. the production manager) to display essential information to the parties involved using data windows.



Web technology is widely used to keep the mass of information as manageable as possible. This concept provides each capital asset (ship) with its own web site (the system portal) that links to all the relevant information.



To manage the plethora of all the technical web sites and also to keep the underlying data up to date, the amico system modeller uses portals with index pages linked to the installations, which in turn are linked to the specific technical web sites. These sites use Active Server Page (ASP) technology. This means that instead of the information being embedded in the web page itself, a script (a program running on the server) collects the data from a specified logistic database on the network. The object of this approach is to ensure that data management can be unambiguous and consistent at minimal cost. Workshops sessions conducted by the Royal Dutch Navy have demonstrated that bad or incomplete information results in irritating communication that hampers collaboration. The consistent use of web-based PDM ensures from the source up that all the available information can be accessed by the parties involved.

