APPLICATIONS AND TECHNOLOGIES FOR MARITIME AND OFFSHORE INDUSTRIES

Industrial Significance of Computer Applications

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Abstract: This paper gives an overview of the computer applications, hardware and software, that were essential in the rapid development of ship technology during the sixties and seventies and the subsequent development of offshore oil technology.

Key words: Industry computing, maritime technology

1. INTRODUCTION

The maritime industry in Norway, comprising ship owners, brokers, shipyards, consultants, research and education institutions and classification society, experienced a strong growth and considerable changes during the sixties and early seventies. An internationally competitive Norwegian shipping industry, operating one of the world's largest merchant fleets and being in the forefront both commercially and technologically, drove this growth. The rapid technological development that took place, not least in Scandinavia, also contributed to this growth. This technological development, which they could not implement without extensive use of computers, also turned out to be of great importance in the first decade – the seventies - of the Norwegian offshore oil industry.

The very rapid build up of a national offshore oil industry, based on national skills and resources, relied heavily on the maritime technology developed during the sixties and the early seventies. Thus, in fact, the early offshore oil industry was part of the maritime cluster, using i.e. to a large extent the same people, engineering skills and computer software and hardware, the same production facilities and the same investors and financial institutions.

The systems that were developed, mainly using UNIVAC 1107 and 1108, from the beginning of the 1960s were a necessary condition i.e. for the design and construction of large oil tankers (the size grew from 60000 tons to over 300000 tons in a decade), the new spherical gas-tankers, special cargo vessels etc. At the same time, process control computers were installed for automatic engine room control, based on a technology to be used later on as in controlling the movements and position of mobile rigs.

The skills, software, and hardware thus available around 1970 could immediately apply to the offshore oil industry in the design and construction of the huge concrete and other fixed platforms such as the semi-submersible mobile rigs and their control systems. The significant Norwegian seismic industry also grew out of the same nucleus. In addition to benefiting the Norwegian and international maritime and offshore technology, these hardware and software developments resulted in an export oriented hardware and software industry.

In Norway, the oil era began in 1967 with the discovery of the Balder Field and the commercially more interesting Ekofisk Field in 1969, changing the industrial and economic structure of Norway. The oil and gas sector now contributes directly to the Norwegian economy with 23% of the GDP and 45% of the export. Norway is the third largest exporter of oil in the world. The yearly investments in the sector amount to around 60 billion NOK and the yearly oil and gas production is worth about 300 billion NOK. The complexity and size of the systems being designed and installed is illustrated by the fact that the cost of developing the Statfjord field alone amounted to around 90 billion NOK.

The "Norwegian content" of the investments in the first phase rapidly approached 70%, which was the political goal. This was an ambitious target taking into account that the investments in fixed and mobile marine structures, process equipment, operational systems and various services was heavily based on completely new technologies to be applied in the very harsh and demanding environment in the North Sea, on the surface and down to more than 500 meters. They met the target fairly soon, partly because much of the basic skills and infrastructure was already in place in the maritime cluster: In shipyards, shipping companies, research institutes, and Det norske Veritas.

In the following, we will give a survey of the application of computers in the design, construction, and operation in the maritime and offshore sectors in the sixties and seventies, showing by a few examples how software, skills and infrastructure developed for the maritime industry could readily be applied to the development of the offshore industry. The present contribution is not based on the thorough research that the topic deserves, but rather on the author's memory, on manuscript of speeches given at various occasions, and on internal notes. Some information also comes from informal conversations with key people from the period in question.

We do not intend to give the full picture. The examples will provide an illustration of the rapid development of advanced ship technology in the 1960s. They will also show the remarkable development of new technology in the following decade in the offshore oil and gas sector, of the synergy between these sectors, and an illustration of the considerable significance of computer application in these achievements. The topics chosen and the description of the examples are naturally coloured by the author's position in Det norske Veritas and its subsidiary, Computas, during the sixties and seventies and through other mentioned achievements.

2. EXAMPLES OF APPLICATION OF COMPUTERS IN SHIP DESIGN IN THE SIXTIES

The increasing demand for transportation of oil made it commercially interesting to use larger oil tankers, bringing the size from 60.000 tons dwt around 1960 to more than 300.000 tons ten years later. This rapid development left the ship designers with great challenges. In earlier times, the criterion for the ship's structural strength related to its longitudinal strength, considering the ship as a beam with variable cross sections. With the larger ships, one had to consider also the transversal strength and the strength of its various components such as plates and frames. This called for increasingly complex and theoretically based methods and calculations, which at that time were part of the ship design, hull as well as engine, to enhance the more empirically based methods being used until then. In 1956, Det norske Veritas started using computers for such calculations. At the same time, a number of new, large shipyards were erected in many countries to handle the building of these large tankers. This also called for new computer based systems in design and production.

These more elaborate methods, like the finite element method for structural analysis and the statistically based calculation of impact of waves on the ship, turned out to be necessary to support the development of new ship structures. The development started in 1960 at Det norske Veritas, inspired by work done by Børje Langefors at Saab Aircraft ten years earlier. Later on in the sixties strong groups were established at NTH in Trondheim.

The first programs appeared in 1960 in a very simple assembly language, almost a binary machine language, on the Ferranti Mercury at NDRE, the Norwegian Defence Research Establishment. They used the capacity of this machine to its maximum to solve the up to 200 simultaneous linear equations involved at that time to take into account the 200 degrees of freedom of the model of the physical system. They were able to augment the capability of the programs when the Univac 1107 was in place in 1963 at Norsk Regnesentral. They could now solve up to 5000 linear equations. The productivity in writing new software increased considerably by using the now available high level languages like Fortran and by using remote batch terminals, like Univac 1004. Because interactive terminals were not available at that time (they were introduced to this application around 1975), a large proportion of the programmers were engaged in creating the user interface.

The users themselves made much of the software development. For example, by 1970 many individuals of the technical staff of Det Norske Veritas were skilled Fortran programmers. At this time, therefore, all disciplines involved in ships and machinery design and related areas used computers.

It became obvious later on in the 1960s as the size of the tankers grew and as new problems appeared (when dealing with new types of ships like the LPG and LNG tankers, developed and built by the Kværner group, with spherical tanks, and carrying liquid gas at very low temperatures) that even more elaborate methods had to be used. They had to take into account more complex representations of the structures, fracture mechanics, nonlinear, thermal, and dynamic effects. As the complexity of the calculations increased and as more and more fields needed computerization, the demand for more computer capacity became obvious, and Det norske Veritas decided in 1969 to install a Univac 1108.

Thus, around 1970, we were able to handle up to 500.000 simultaneous linear equations, which was necessary to analyse the LNG Tankers. We should note though, that in order to do this one had to utilize the a priori information one had about the internal pattern of the structures and the matrixes representing them, for instance the bandwidth and the multilevel system of substructures. Using machine code and double precision in the inner loop of the equation solving routine were necessary to maintain accuracy without increasing computer time too much. Nevertheless, it took a whole night to perform a complicated calculation. This was rather exciting when the mean time between system breakdowns was less than 12 hours in the first year of operation of the Univac 1108.

To do such analysis (the finite element analysis being only one out of several other important applications), the introduction in 1963 of Univac 1107 at NR with the remote batch terminals and good Fortran compilers, and later on 1108 in 1969 were just in time and necessary for the development. Another key to the development were the methods and software, named SESAM, developed at NTH during the late sixties and acquired by Det norske Veritas in 1970. This system were used extensively in the coming years by Det norske Veritas who also developed it further and brought it to the world market, an activity that today are still bustling with a staff of 150 in marketing, maintenance and support.

3. TRANSFERRING SKILLS AND USING THE INFRASTRUCTURE IN THE OFFSHORE DEVELOPMENT

The first achievement of computer application in the offshore development was the design analysis of the Ekofisk Tank, a huge cylindrical structure, built in concrete and steel, 100 meters in diameter and placed on the bottom, 70 meters below the sea surface. To calculate the structure they had to use the most advanced finite element programs together with the newly developed, statistically based methods for assessing the impact from the waves on the structure. To illustrate the transfer of technology, they used the same methods, the same software, even the same people as they were in designing the large LNG tankers. When the Aker Group designed the new generation of mobile platform, the H3, the finite element programs were indispensable tools.

The next technological break-through came with the introduction in 1974 of the huge concrete platform, Condeep, still operating in many waters around the world. Completed in 1995, the largest of these platforms, including their topside processing plants, are up to 450 meters tall (the tallest structure on earth at that point in time), placed in deep water with only its topside above the surface. The Norwegian consultancy firm, Dr. Techn, designed the Condeep platform. Olav Olsen, in cooperation with Norwegian Contractors, a Norwegian construction company, also developed the unique production method. The design required extensive dynamic and non-linear finite element calculations.

Again, it was the same group of people, mostly employed by Computas, a Veritas subsidiary, that did the calculations, using the same methods, the same software, and the same infrastructure. This time one overall analysis of the structure required a mesh of several hundreds of thousands elements, with up to three millions of degrees of freedom. The solution of the resulting several millions of linear equations took up to six days on the 1108 requiring continuous surveillance and complicated logistics to restart if anything went wrong, which sometimes occurred, even if the mean time between system breakdowns on the 1108 at that time (1974) was considerably longer than a few years earlier. The Condeep analysis was, however, so frequent and extensive that they acquired computer time on several 1108's around Europe (in Basel, Oberhausen, and London). Needless to say that this was before Norwegian government introduced the Working Environment Act (Arbeidsmijøloven).

4. OTHER EXAMPLES

4.1 The Autokon and related systems

The Autokon system for computer-aided design of ships, developed in the sixties by SI (Sentralinstitutt for Industriell Forskning, The Central Institute for Industrial Research) in cooperation with the Aker Group. Trygve Reenskaug covers this in his paper in these Proceedings. This system played an important role in the design and building of the large tankers and other modern ships as did the related systems and equipment for design and manufacturing automation (drafting and cutting equipment, etc.) and the production control software developed in cooperation with the Kongsberg group. All these systems, based on SI's mathematical modelling of 3-D surfaces and their database design were important tools when the large shipyards were converted into offshore yards in the seventies, then building huge mobile and fixed drilling, production and accommodation platforms.

4.2 Process automation

The first Nord computer was used in the Taimyr-project, a joint effort between Institutt for reguleringsteknikk (Institute for Control Engineering) at NTH, SFI (the Norwegian Ship Research Institute), the shipping company Wilh. Wilhelmsen, Det norske Veritas, and Norcontrol. In this project, completed in 1970, they installed a minicomputer for the first time onboard a merchant ship to control the engine room operation. The result of the project was a system that allowed for unmanned engine room, which was a great achievement both when it comes to safety and cost. There were at the same time other efforts to install minicomputers onboard to control the operations, but the Taimyr project was the most successful, bringing Norcontrol in front of the development and the Nord computer to the market. Norcontrol is still a market leader with this application.

The skills that were developed was one of the cornerstones in the later development of many process control systems in the offshore sector, for instance the mobile positioning systems developed and produced by The Kongsberg Group to control the movements and position of the mobile platforms and vessels operating at the offshore oil fields. Also this application, like many other successful developments in computer applications in this period of time, had its roots at Institutt for reguleringsteknikk (Institute for Control Engineering) at NTH.

4.3 Seismic exploration

In 1972, Det norske Veritas established the marine seismic company, Geco (Originally Geoteam-Computas AS), through its subsidiary Computas in cooperation with Geoteam, a consulting firm specializing in geophysics and geology. The basis for the establishment was the geophysical group of Geoteam, having for several years being conducting seismic surveys on land and at sea, and the computer and instrumentation activity at Det norske Veritas, including the Univac 1108.

The marine seismic activity consists basically of two activities. Firstly, seismic data are acquired by a large number of sensors attached to one or more cables of considerable length (i.e. 5 km.), towed after a vessel cruising at low speed, at that time usually a converted trawler or supply ship. By sending signals to the sea floor, the signals penetrating further and reflected by the geological layers beneath, and picking the reflected signals up by the sensors, they were able to collect a huge amount of raw data.

Secondly, they had to process the reflected data to make the data understandable to the geophysicists and geologists. This data processing is advanced signal processing, using various correlation and de-convolution techniques that require the computer to perform a huge number of operations, proportional to the second or even third power of the number of data. With 24 groups of sensors and a sampling rate of 4 milliseconds, which was state of the art in the 1970s, one can imagine computer time that was necessary to process the bulk data (approx. 20 billions of numerical data) each day. It soon turned out that the 1108 was to slow and that dedicated computers with array processors were better suited for this task.

In the first half of the 1980s, Geco had 1500 employees, operated 15 vessels, seven data processing centres around the world, and two manufacturing plants. It made its own electronic equipment, thus being one of the largest and most profitable seismic companies in the world. The geophysical industry in Norway now consists of several companies with total sales of approximately 1 billion dollars and with more than 50% of the world market for marine seismic services. Most of these companies have their roots in Geco.

4.4 Software export services

For most of the software development described in this paper and in the Autokon paper, the objective of the development was in the first place to make the participating industry, like the Aker Group and Det norske Veritas, more competitive. Very soon, it turned out that it was possible to develop profitable business on services based on the software; the potential for exporting it also was present. The first overseas installation of the ESSI-Autokon combination was at the General Dynamics, Quincy Yard, Massachusetts, in 1965. This could be the first major application exported from Europe to America. Major shipyards all over the world eventually adopted Autokon. Three distinct technologies emerged from this project: mathematical modelling, data base technology, and personal information systems. They formed the basis of several systems that came onto the market by a number of companies in the following decades.

Det norske Veritas decided in 1966 to start selling the software programs they developed and the services based on them. This led to the establishment of the subsidiary, Computas in 1968, with the main purpose of selling the software that Det norske Veritas had developed. The Aker group also established a separate subsidiary, Shipping Research Services, to market Autokon and related software.

The finite element programs were the most sold software of the Computas portfolio. It also brought to market a large number of other applications within shipbuilding, offshore industry, mechanical industry, and civil engineering. They sold the programs to almost all industrialized countries in the world in the following decades and they established service centres in most of the major Veritas offices around the globe, mostly in conjunction with the local Veritas office. The economic results of the export activity in Computas were not spectacular in the first years. However, it contributed considerably to the necessary maintenance and further development of the software and its use, and to the success of Det norske Veritas in its worldwide operation. The Sesam system is still operative with some 150 people engaged in marketing, maintenance, and user support after having sold around 300 licenses of the system. However, today they integrated the system with other software into a much more extensive information processing and production environment.

Let me mention one thing as a curiosity. In the late 1980s, the author received an inquiry from Korea about a bug that someone found in the software that he developed in the mid-1960s. That is a long lifetime in the computer business.

5. CONCLUDING REMARKS

The applications mentioned in this paper were undoubtedly successes. We have omitted the many failures. Success has many fathers; failure is an orphan, as the old saying goes.

Most of the successes were obtained in broad multidisciplinary milieus and in areas with extensive cooperation between business, research institutes and NTH and where all parties (including the users) were operationally involved. This was especially true towards the end of the 1960s and in the 1970s, a substantial number of people switched between the various institutions and companies. It turned out that we achieved the best results in projects where the participants were on equal footing with a common goal, and not where one being regarded the sub-vendor of the other.

A typical feature of the milieus involved was the presence of *basic* technological understanding. This made it possible to apply the skills to the new areas of development. We demonstrated this when we showed the transfer of skills in ship design, production, and operation to the development of the offshore oil and gas industry, or when the skills in mathematical modelling obtained by developing the methods for automatic ship design were transferred to the design of ocean wave power plants. Another typical feature was the lack of distinction between programmers, systems designers, and experts in the subject matter.

Is there anything to learn from the story briefly outlined above? We developed most of the skills and software in an environment where leaders in business and academia allowed creative people with visions to use their energy to realise the visions. The bureaucracy was almost not present. The achievements were not the results of formalized strategic plans and strict control, but the results of visions. There was hardly an accountant around to demand cost-benefit analyses. The people involved were extremely dedicated and had what they considered obvious goals and the necessary authority, and mostly the economic resources to reach them. The successes were not the result of user initiative and *control* (brukerstyring), but end-user *involvement*, also operationally. (Is this just wishful thinking supported by a fading memory? Perhaps not.)