Applications and Technologies for Maritime and Offshore Industries.
Technological Significance of Early Norwegian Applications

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Abstract. *Autokon, a CAD/CAM system for ships, was one of the most important early Norwegian applications. We describe the background for the Autokon project and its results. We will specifically follow three technology threads that we have called* Data-centred architectures*,* Mathematical modelling*, and* Personal information systems*, where the last one includes distribution and component based architectures. An important part of the Autokon background is the history of the earliest computers in Britain and Norway. We therefore start with a brief history of computing.*

1 Introduction

The Second World War was to a large extent a war of science. It was a war of electronic navigation measures and countermeasures: *"The early detection and partial frustration of Knickebein - a feat known only to a few - was an early and major British victory in the Battle of Britain"* [Jones-98]. Even more important was the breaking of the Enigma code used by the German navy, army and air force. This critical work was started by the Poles and completed by the British by means of electro-mechanical computers called *Bombes*: *"Between 1939 and 1945, the most advanced and creative forms of mathematical and technological knowledge were combined to master German communications. British cryptanalysts, Alan Turing at the forefront, changed the course of the Second World War and created the foundation for the modern computer"* [Sale]. The code used by the German high command, the Lorenz code, was also broken by the British using the world's first electronic digital computer, the Colossus [Small] [Colossus]. By the end of the war, the British had built 10 Colossi. This gave them invaluable experience with the design, construction and operation of digital computers. An experience that gave them a head start over the Americans who only got their single ENIAC operational more than a year after the first Colossus. We give more details of this interesting story in section 2, introducing the roots of some early Norwegian computers.

In this paper, we take Norway's first computer and the *Autokon* project as our main starting point. Autokon is a system for the computer aided design and construction of ships. Its vision is a data-centred architecture with a product model in a central information store surrounded by a number of application programs that support various shipbuilding activities. It first went into production at the Stord shipyard in 1963. Most of the world's major shipyards later adopted Autokon. We describe the Autokon project in more detail in section 3. Three technological threads that grew out of this project are discussed in sections 4, 5 and 6.

Different milieus grew up around each of the early computers in Norway. We do not claim that Autokon was our most important early application; but it happens to be the one we are familiar with. This means that we will not go into the important developments that grew up around our second computer, the Ferranti *Mercury* at Kjeller. Object orientation and *Simula* [Simula] sprang out of this nucleus. So did the international minicomputer company *Norsk Data* and the computer-based activities of *Kongsberg Våpenfabrikk. Norcontrol* was established 1965 for the exploitation of an anti-collision and machine room control system for M/S Taimyr. *Kongsberg Maritime Ship Systems*, the world's largest supplier of ship automation and control systems, can trace its history to this project.

Other early applications proved to be significant in various ways. Most of these were important for a single organisation only, while a few had wider impact. An example is the simulation of waterpower reservoirs with their installations of electrical power generators at the *Norwegian Water Resources and Energy Directorate (NVE)* that started on the *Facit EDB 3* in 1960. Better overviews of early Norwegian computing can be found in the papers by Drude Berntsen [Bernt-03] and Trond Vahl [Vahl-03] at this conference.

2 The roots of the early Norwegian computers

2.1 The first British computers

The German High Command used a code nicknamed "Fish" that was more sophisticated than the Enigma code used in routine operations. The British managed to break this code with the aid of *Colossus*, a special purpose parallel computer with more than 1500 valves. Registers were in the form of thyratron rings; main memory was a loop of paper tape continuously read at 5000 characters per second. The Colossus was programmed to a limited degree via its plugboards and switches. The first Colossus went into full operation in January 1944, and by the end of the war there were ten Colossi in operation at Bletchley Park [Colossus]. Colossus was top secret, known only to a select few in Britain and the U.S.A. [Small].

Another special purpose electronic computer was the American *ENIAC* designed for ballistic and other computations. It was gradually put into operation from June 1944, and was only completed in the fall of 1945. [ENIAC] reference calls it "the world's first electronic digital computer". This is clearly wrong, since 10 Colossi preceded it.

Colossus and ENIAC were electronic digital computers programmed via plugboards. The concept of a stored program computer was first suggested by Alan Turing in his seminal paper that appears to have been written while he was at Princeton under von Neuman's eye [Turing-36]. By 1946 the pressing needs of war were over and a number of people on both sides of the Atlantic were ready for the next step. In July and August 1946 there was a series of 48 lectures at the Moore School of Electrical Engineering [Moore-49]. 28 people attended from the U.S. and Great Britain. Threads from the ENIAC and, indirectly, the Colossus were merged with Alan Turing's complete design of the previous year [O'Connor] and the ideas of von Neuman, Eckert, Mauchly and others. This must have been a memorable event for all participants with a flow of ideas and much enthusiasm. It must also have been a very frustrating event for the British participants because the Official Secrets Act prevented them from giving the audience the benefit of their deep Colussus experiences. Nevertheless, it appears that all participants went home eager to realise the computer vision.

The Colossus was top secret, yet the accumulated know-how migrated after the war together with its developers to various British research establishments. A highly productive computer community was at the *University of Manchester*. The word's first stored program electronic computer appears to be the *Manchester Small Scale Experimental Machine*—"The Baby" [Baby] that executed its first program as early as on 21st June 1948. Baby was designed for testing the Williams-Kilburn cathode ray tube high-speed storage device. It was truly minimal computer with an operations repertoire of just 7 instructions. Baby lead through several stages to the design of the *Ferranti Mark 1*. The first machine off the production line was delivered to Manchester University in February 1951, allegedly making it the world's first general-purpose commercial computer.

A group at the University of Cambridge started work on the *EDSAC* computer in October 1946 as one of the developments following the Moore School Lectures. EDSAC ran its first program 6 May 1949 when it computed the squares of 0..99. This made it the first complete and fully operational regular electronic digital stored program computer [EDSAC].

2.2 The first Norwegian computers

We now get to Nusse, the first Norwegian computer. There was a committee, *Utvalg for matematikkmaskiner*. There was an instigator, *Henry Viervoll*, who was working with X-ray spectra and needed a computer. And there was an achiever, *Thomas Hysing*, who made it happen. A decisive event was a visit to the committee by Professor D. R. Hartree who was involved with the EDSAC work at Cambridge. He strongly recommended that the committee should go for an electronic stored program computer. The result was that Hysing spent a half-year at the EDSAC laboratory in 1949. A computer on the scale of EDSAC could not be financed in Norway at that time. Through his work with X-ray spectra, Viervoll had contact with Andrew D. Booth at Birkbeck College, London. Booth had plans for the APEXC computer (All Purpose Electronic X-Ray Computer) [APEXC]. These plans were modest and within reach for the Norwegians [Hy-03]. The Norwegians subsequently acquired APEXC(N) in kit form, a kit that proved to be both incomplete and unsound. Hysing and his crew at the *Central institute for industrial research* (SI) got the computer up and running in the spring of 1953 after a number of modifications and extensions [museum]. By 1954 she was sufficiently stable for her operation to be taken over by the *Norwegian Computing Centre* (NCC).

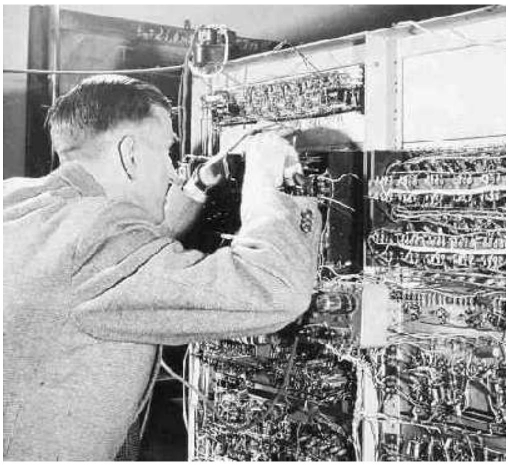

Figure 1: Reliability was the key problem with the early computers.

Nusse's main memory was a rotating drum with 512 32-bit words. Input/output was with 5-channel paper tape in addition to a Teletypewriter printer. There were three main registers called *Ar*, *Mr*, and *Or*. Nusse used a 1+1 operation format as follows: Not Used *b* (1 bit), Counter: (*n*, 7 bits), data address: (*x-addr*, 10 bits), operation: (*Op*, 5 bits), address of next operation: (*y-addr*, 10 bits). The latter was important since it enabled optimisation by making sure that the next operation was under the read/write head when it was needed. There where 16 basic operations. *Operation 14*, for example, transferred the (32-n) least significant bits from *Ar* to memory in address *x-addr* and fetched the next operation from *y-addr*. Basic operation time was about 1 ms, but could be as high as 16 ms if it had to wait a complete turn of the drum for its data. (And 32 ms if it had to wait another turn for its next operation). [AmEvj-53]

Nusse was decommissioned in 1961 when her last project, the development of Autokon, was ported to the Swedish *Facit EDB 3* at the Norwegian Meteorological Institute.

The Swedish government took an early initiative for building computers in Sweden. A committee, *Matematikmaskinnämden*, was established as early as December 1948. Their first electronic computer, *BESK*, was completed in November 1953. Facit developed *Facit EDB 3*; a commercial product based on the BESK. The first Facit machine was completed in 1957. For a short period, Facit EDB was the fastest machine in existence. A Facit EDB 3 was installed at the *Norwegian Meteorological Institute* (NMI) in July 1961, making it the third meteorological institute in the world to get their own computer.

Facit EDB 3 had a core memory of 2048 40-bit words or 4196 half words of 20 bits. I/O was paper tape and punched cards; printing was off-line via punched cards. There was a core-based buffer of 4096 40-bit words and a drum secondary store. An operation was held in a half-word with 12-bit address and 8-bit operation code. There were no index registers so indexing had to be done with arithmetic on the instructions. The interesting random access "carousel" tape station ECM 64 had a removable wheel with 64 tape spools; each spool could hold 8192 40-bit words. A read or write operation was in two steps. First position the carousel for the required spool, then read or write the data blocks off that spool [Facit].

The Facit was the engine for the first Autokon production runs. The database for a ship was held on one Facit carousel. Autokon was subsequently ported to FORTRAN on NCC's Univac 1107. This computer was the first large-scale computer in Norway and had an immense impact after its installation in August 1963 [Elgsaas].

Another event that proved important to our story was the arrival of an *IBM 650* computer in Bergen in 1958 at AS Emma. This supported a strong computing group at the *Bergen Mekaniske Verksteder* (BMV) shipyard. This group developed original shipbuilding applications that were later integrated into Autokon. AS Emma thrived and had 260 employees in 1985 [Emma].

3 Shipbuilding with ESSI and Autokon

We start our main story at SI in 1959. Nusse was in full operation and was used in a number of scientific and technical applications in shipbuilding. These applications were most notable for their influence on future events. One of these events was the invention of *ESSI*, a patented, special-purpose device for numerical control [Kveim-61]. This controller had a curve generator for guiding a tool along straight lines, circular arcs and parabolas. The first installation was for the control of a flame cutter at the *Stord Yard* in the autumn of 1960 [RBj-03]. The Stord Yard people were highly attuned to new technology. For example, they computed tank-sounding tables on the Facit EDB in Gothenburg as early as 1959.

Kongsberg Våpenfabrikk later marketed ESSI for the control of flame cutters and other machine tools as well as the *Kingmatic*, a very large and highly accurate flatbed plotter for shipbuilding and many other industries. The ESSI code format is still used in the industry.

By 1958/59, the scene was set for Thomas Hysing to merge the ideas of computers and numerically controlled machine tools into the vision of a digital basis for the design and construction of ships. He presented it at the first IFAC congress in Moscow in 1960 [Hy-60]. The vision covered the complete ship design process from owner's specifications to the construction in the yard as shown in figure 2.

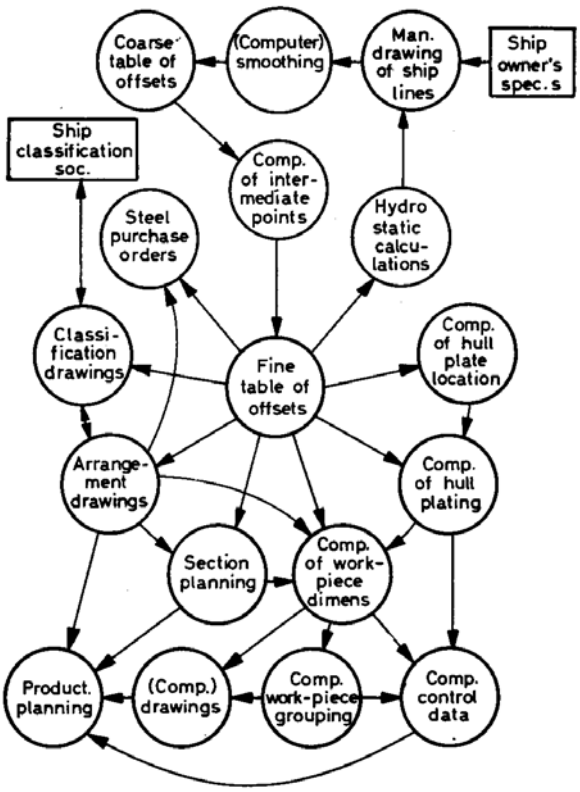

Figure 2: The computerised shipyard

"The most remarkable difference is that in the future digital computers will take over much of the design work which now is carried out by manual means. In the illustration shown it is assumed that manual labour is needed to any great extent only for the first drawing of the ship lines, for the making of ship arrangement, possibly also for classification drawings and for section planning. The rest of the work will eventually, for the greater part, be done by digital computers." [Hy-60]

The idea was to begin at the end and produce control tapes for the numerically controlled machine tools before gradually working back towards the early design stages. This was an important decision, because it made it essential to work with a complete and accurate numerical product model from the very beginning. It also forced the developers to understand and include all the small production details and considerations required in generating production data tapes for NC machines.

In 1959, MIT announced the Automatic Programmed Tools [APT] programming language. In 1960 followed Direct Numerical Control (DNC). The ESSI controller, therefore, appears to be among the first DNC controllers in the world. More importantly, APT was a language for specifying cutter location data sets so that its scope was restricted to the interface between a completed design and the machine tool. Contrast this with Hysing's vision that covered the complete design process; probably making it one of the first examples of true Computer Aided Design/Computer Aided Manufacturing (CAD/CAM). Even today, nearly half a century later, many CAD tools are merely automated draftsmen. They are neither integrated with a product model at the conceptual end nor with the machine tools at the physical end.

The *Central Institute for Industrial Research* (SI) in Oslo submitted a proposal to the *Norwegian Council for Scientific and Technical Research* (NTNF) 30 November 1959 [Proposal]. The proposal was accepted and the Autokon project started August 1960. (Those were the days! Only 7 months from proposal to project start.)

The proposal sketched the ship production process from the owner's specification through delivery. It focused on the lofting and detail design activities and the transition to construction (where the ESSI-controlled flame cutters created the ships parts from numerical information). The six main modules in the proposed system were:

1. Fairing of sculptured surfaces.
2. Plate part definition for planar surfaces.
3. Automatic detailing based on end user programming..
4. Nesting plate parts in a raw format and producing numerical control data.
5. Automatic plotting and final checking.
6. The central database system

System design and development started August 1960 [HyRee-63]. Autokon went into production at the Aker Stord Yard on the West Coast of Norway in 1963 where it formed the cornerstone in their continuous efficiency improvements for building a stream of supertankers. The programs were run on the Facit, and the public five-channel Telex service was used to transmit Autokon part specifications and computed ESSI tapes between SI in Oslo and Stord Yard on the West Coast. The reliability of this service was excellent and no serious difficulties were recorded during its several years of service. (This was fortunate, because nobody had thought to add redundant checking information to the data tapes).

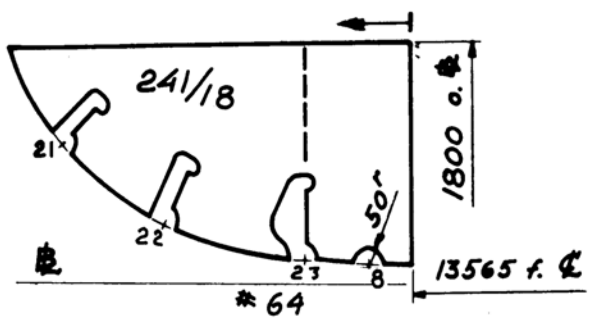

Figure 3: Example part

Figure 3 shows an example of a part. The curved contour is taken automatically from the hull shape. The positions and dimensions of the cutouts for longitudinal frames are determined by the positions and dimensions of the longitudinals. This information is automatically taken out of the database and adjusted for the skew angles between the part and the longitudinals.

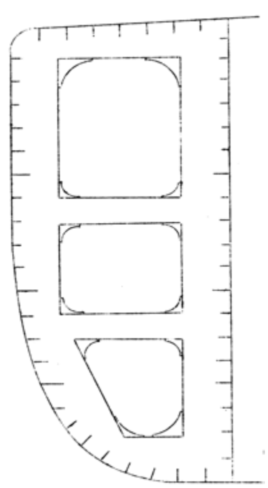

Figure 4: Example of simplified steel design drawing.

The first version of Autokon covered the pre-production stage with detail design and lofting. Work with the previous stage, steel design, started as soon as the first version was up and running. The result was called Autokon II, a system that integrated a large part of the ship design process. Figure 4 illustrates an automatically designed web frame. The figure is taken from the Autokon II project proposal and does not show the rich details of the actual design drawings.

The first overseas installation of the ESSI-Autokon combination was at the General Dynamics Quincy Yard, Mass. circa 1966. This could be the first major computer application exported from Europe to America. Autokon was subsequently adopted by major shipyards all over the world. Product functionality was steadily extended over the years. The original architecture still proved viable when the system was converted from workstations to PCs in the early nineties. Autokon is still in production in many shipyards around the world more than 40 years after its original design and implementation.

Bergen Mekaniske Verksteder (BMV) was one of the initiators of the *Emma* computer. One of its first projects related to preliminary design computations. This evolved into the *Prelikon* system that was later integrated with Autokon and marketed as part of the product. In 1966, the *LOCOS* part programming system developed at BMV was merged with the Autokon Part Program after BMV had become part of the Aker Group.

In the rest of this paper we will follow three significant technology threads that started with the Autokon project. We will present these threads under the headings of *"Data-centred architectures"*, *"Applied Mathematics"*, and *"Personal Information Systems"*. We will study these threads from a Norwegian perspective, but it must be kept in mind that we have at all times been tightly coupled to the world-wide community of computer technologists. We conclude this paper by seeing the Norwegian efforts in the light of international developments in the past and in the future.

4 Data-centred architectures

A central part of the Autokon project was the development of a full-fledged database system called *Filemaster*. The sheer draught is the foundation for most of the ship design work. In Autokon, it is a centrally placed table of offsets as shown in figure 2. From the very beginning, this was translated into an Autokon system architecture with the sheer draught stored in a central data store and various programs organized around it. It was quickly found that this central, random access store should be the repository for a numerical model of the ship including the position of decks and frames as well as the shapes of individual parts. It also included user-defined programs for generating the parts (called Autokon *norms*). In the first production version of Autokon, the database for one ship was held on one Facit ECM64 carousel.

Filemaster's access model was based on geometry; it was easy to find a part's record directly from the part's co-ordinates or indirectly by navigating from a part to its spatial neighbours. A part was stored as a dataset with some common information followed by an ordered collection of curve segments describing the part's contour. Each curve segment was stored on canonical form and represented a straight line or a circular or parabolic segment.

The Filemaster system was made into a separate product and commercialised by *ICAN* under the name of *Autobas*. This product evolved into *Tornado*, a knowledge repository.

Another independent and important database product developed at SI was the navigational database system *SIBAS*, a cornerstone of the Nord computer's software library. SIBAS was the kernel of the *Maplis* system for materials management. Stord Yard was the first Maplis user. It has later evolved into a modern material management system and is marketed under the name of *Sireko MIPS* [Sireko].

5 Applied mathematics

A ship is essentially constructed from a number of plane parts that fit within the space bounded by the doubly curved surfaces of the hull (the sheer draught) and the main deck. The first version of Autokon used a very primitive method for the definition of the sheer draught. It was soon replaced by a sophisticated system based on a mathematical model that minimized the deformation energy in splines with varying cross-section. This method corresponded to the earlier manual methods and the generated curves were very well received by expert loftsmen. The algorithms and computer programs were called *KURGLA* (KURve GLAtting) [Mehlum-69]. A special feature of KURGLA was that its curves were computed as sequences of straight line and circular segments. They could, therefore, be used directly by the ESSI controller without any further approximation.

KURGLA was commercialised from around 1968 when the Aker Group (ships), Hawker Siddeley (UK, aircraft) and British Leyland (automobiles) co-operated to extend KURGLA for use in the water turbine, aerospace and car industries. The new product was delivered to the users in 1974 and marketing and maintenance was taken over by Shipping Research Services, the Autokon marketing company.

The Group for Applied Mathematics at SI sprang out of the 3D surface definition work in 1961. One of its first projects was to generate synthetic holograms from a computer-based definition of a shape. A simulation program used the differential equations for wave propagation in optics to compute the holographic interference patterns. The physical patterns were created photographically on a Japanese *JEOL* electron microscope that was specially modified for computer control of its electron beam. The result was probably the world's first computer-generated optical holograms. Some spin-offs from this project can be found in modern offshore seismic technology.

Another spin off was a method for the design, construction and testing of holographic lenses in 1977. Lenses were developed for the focusing of ultrasound, infrared light, and water waves. The latter were particularly interesting since such lenses enabled the focusing of ocean wave energy in power stations. A Company, *Norwave,* was established and the first prototype wave-powered generating station was completed in 1985.

6 Personal Information Systems

The first version of Autokon consisted of a number of tools designed for the ship designer. One of the applications included a designer's language for the generic specification of plane parts. Autokon II came around 1965 and evolved into Autokon -68 and -71. The user community was now extended to the steel design department, and one of the applications included a ship designer's language for the definition of generic designs.

The long term goal for all Autokon work was to look at the shipyard as a socio-technical system where organisation, individuals, computers and machine tools are equally important: *"The goal is that we shall create a system that optimally combine human insights, experience and imagination with the computer's speed, accuracy and capability for managing large sets of data."*

An important insight was caused by a blunder. The steel design and lofting departments shared a common database. Steel design produced the numerical equivalent of the old 1:50 drawings. A bright lad in lofting recognised that all information was now precisely represented in the database. Presto! Control tapes for the flame cutters could be pulled straight out of the database. They cut more than 300 tons of steel before discovering the difference between precision and accuracy. Yes, the data in the database had 40-bit precision. No, dimensions were still as approximate as they had been in the 1:50 drawings. 300 tons of scrap steel and some angry finger pointing was the result.

The blunder itself was of course easily fixed and never repeated. Many results from steel design could be used as long as they were carefully checked, corrected and augmented in lofting. But the real problem was a deep one. In the manual system, the steel design department had ownership and full control over their information. Similarly, lofting had control of *their* information. And most important, the transfer of information was formal and carefully controlled by both sender and receiver. We believed the required solution to be fundamental and general: *The computer system must mirror the line organisation and the line departments must remain in control of their data and their programs.* The systems should be interlinked in such a way that transfer of information can be computer assisted, but must remain under human control.

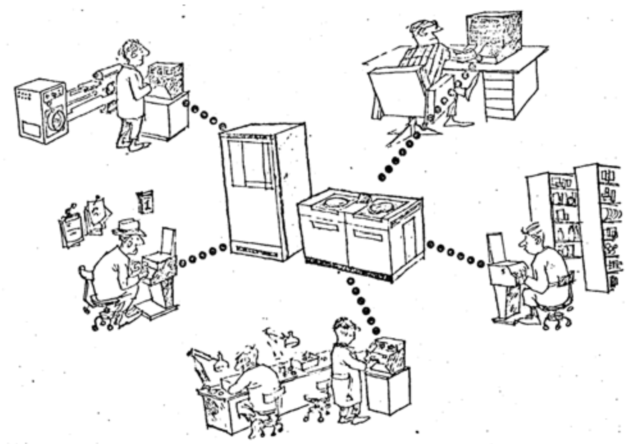

Figure 5: Production control in custom manufacturing

The first application according to this paradigm was NIPOL. This was a system for the dispatching and control of production at A/S National Industri, a major Norwegian manufacturer of large power transformers. *"The NIPOL project is a first step towards a new type of systems, system that build on the individual and his needs, and for use in the daily work."* (Freely translated from [NIPOL]). The system architecture is visualised in figure 5. The total system had several "owners": the machine tool operators, the foremen, the planners, store room personnel, etc. The application was implemented around 1970 on a Nord-1 and later ported to Kongsberg's SM-3. NIPOL was commercialised by Kongsberg Våpenfabrikk and had some success in Sweden.

The next step along this thread was the vision of a total, distributed information system for the shipyard. The system should reflect the yard's line organisation with tight coupling between local components and loose coupling between organisationally distant ones. The vision was heavily rooted in current organisation theory with self-governing groups etc. and was proposed as a research program under a title that went somewhat like this: *The data systems of the 70-ties. A fundamental proposal*. The vision was later published in [Ree-73].

The vision unites two conflicting requirements. On the one hand, a person needs to see a coherent information space that is structured according to the person's mental models. On the other hand, the enterprise requires that various functions such as planning and control, accounting, design, materials management, etc. are integrated both individually and jointly.

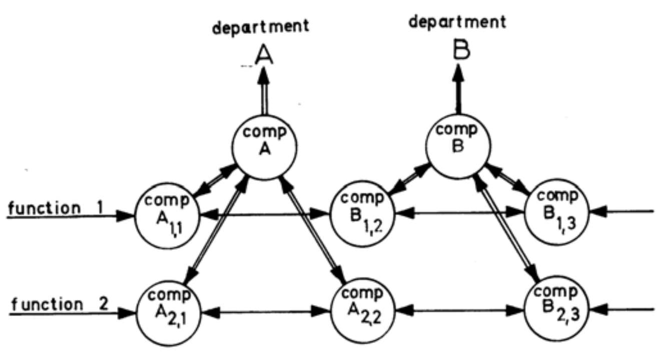

Figure 6: Two decomposed functions. Each component is controlled by the responsible department

The solution was a structure of communicating components in a matrix as visualised in figure 6. Each function is decomposed into a number of communicating components. The system architecture is such that each unit in the line organisation owns a group of components. Each user's information space is realised by a user-near component called a *toolset*. The user could here be a person or a department [Ree-73].

The first project to build on this vision was *Prokon/Plan*, a distributed system for planning and control in the shipyard. The goal was to loosen up the centralised and rigid planning system. The idea was to replace the "dumb" activity and resource records of the standard planning program with "smart" objects that would be owned by the various users who would control not only their data but also the way they did their work. So the piping design department could plan and control differently from the lofting department, while the panel assembly line could be handled differently again. The key to success would be to find ways of integrating the plans from the different departments. It was clear that the overall planning process had to be transparent and comprehensible. The line not only needed to understand the process; they must be able to define it and to redefine it quickly to resolve urgent problems.

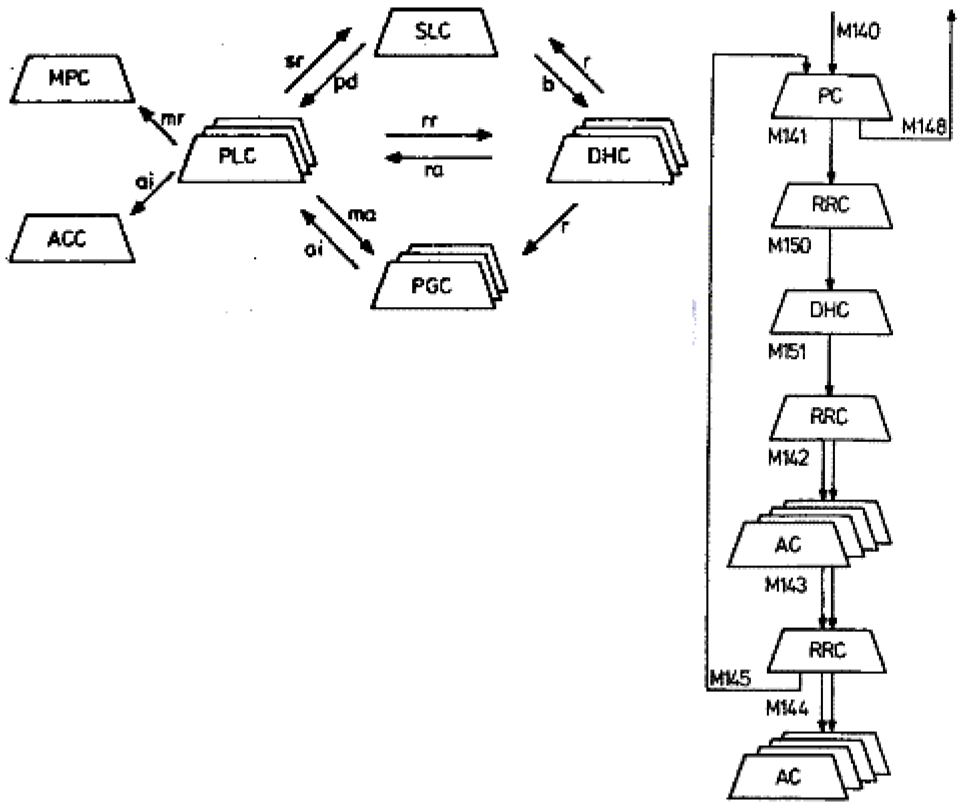

Figure 7: Example component structure and interaction diagram.

The Prokon/Plan project got under way and an experimental application was implemented. A first version written in Simula was abandoned because its rigid typing system made it hard to code the interaction of very different components. A first experimental version was finally written in Fortran with a pre-processor that made it somewhat object based. Then an acute oil crisis abruptly removed all funding and the project died. This was probably just as well; in retrospect the project seems technologically premature. The project was reported in [Ree-77], two of its diagrams are reproduced in figure 7. These diagrams could be the world's first examples of what in UML is called *collaboration diagrams* and *message sequence charts*.

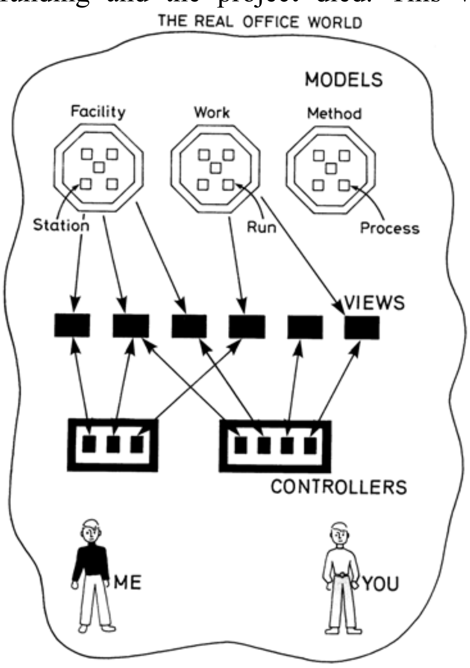

Figure 8: The Model-View-Controller paradigm, an industry standard that sprang out of Prokon/Plan

Experiments with user interfaces to a large, distributed and component based plan continued at Xerox PARC in 1978/79. This time the programming was done in Smalltalk, Alan Kay's pure object oriented personal information environment based on Simula with the addition of the human-centric thinking of Douglas Engelbart and the extreme uniformity of Lisp. One result of the work was the *Model-View-Controller* paradigm that is illustrated in figure 8. Business information is held in background *model* components. The users have task oriented *controllers* (tools) that may appear on a computer screen as a window with one or more panes (panels). Each pane holds a *view* on a certain aspect of a model. The MVC can exist in many variants and is now industry standard. (More in [Ree-03])

We end this thread in the early eighties. An early, wholly object oriented application, *Tender One*, was demonstrated at the first OOPSLA conference in 1986. The product was a tool for tender preparation that seamlessly mixed text, tables, and drawings with results computed from data in a database. The application failed as a product because it required a special workstation and lacked integration with common text processors such as Word®. Another initiative was the *Eureka Software Factory*; a major attempt at creating a software development environment based on the above ideas. The project did not end up in a product because the industrial partners, two minicomputer manufacturers, faded out of the picture.

7 Where are they now?

Autokon. It is estimated that there may still be as many as a dozen Autokon sites around the world, 40 years after its first production run. It was at its commercial apex in the eighties until the glory of the YAPs pulled the rug under the marketing company. The Autokon operation was then acquired by its Swedish competitor, *Kockums Computer Systems*. Autokon is now merged with Kockums' Steerbear into the *Tribon system* that currently is the world market leader.

Data-centred architectures became mainstream with the database systems from the late sixties. The Autokon database system itself was extended and commercialised by Metis A/S under the trade name of Tornado. This activity has ended up in *Computas AS* with the software product Metis® "*Visualising Your Enterprise Knowledge*". Metis is marketed internationally with offices in Norway, Sweden, and North America.

Mathematical modelling evolved into more general mathematical modelling of physical phenomena, in particular wave phenomena The value of general and sound understanding of a scientific field can be illustrated by the diversity of applications from the mathematical modelling group: [math]

1. The design of lenses for the focusing of sound waves.
2. Platforms in the North Sea are exposed to extreme wave loads. Calculations of forces from waves hitting the legs of the platform are important to the safety offshore.
3. Computation of how ocean waves are refracted off the coast. The project *Geosim* demonstrates the use of Geographic Information Technology (GIT) in numerical calculations of natural phenomena.
4. Scientific visualisation of data from a supercomputer models. A weather map over Europe is generated by the NIMBUS software, which was developed at SI/SINTEF. This was the predecessor of the weather forecast system used on the Norwegian TV2. The program is being further developed by *Weather One* in co-operation with SINTEF Applied Mathematics.

An experimental water wave focusing device was tested in Hakadal near Oslo in the autumn of 1979. This lead to the invention of the "tapered channel" principle for concentrating ocean wave energy. A pilot power plant at Toftestallen in Øygarden outside Bergen utilized this principle. It was finished in 1985 and worked according to theory until 1991, when a contractor accidentally blasted several tons of rock into its focusing channel in conjunction with an experiment. In 1998, a Norwegian team coordinated by *Indonor AS* and including *Norwave AS, Groener AS* and *Oceanor ASA* won a contract to deliver a *Tapchan*® (tapered channel) wave power plant. The site, at Baron on the south coast of Java, utilises a bay with its own natural basin. The 1.1 MW plant was planned to harness power from waves entering the 7-metre wide mouth, flowing down a narrowing channel, being forced over the walls of the basin (reservoir) and being returned to the sea via a conventional low-head turbine. [waves].

Together with the University of Oslo, the mathematical modelling group is now establishing a Centre of Excellence for mathematics for applications

The work with *Personal Information Systems* evolved into object oriented role modelling. The associated modelling tool, *OOram*, did not prove commercially viable, but its conceptual model was fed into the OMG standardisation process [UML-Prop-97]. These concepts are now part of the *Unified Modelling Language (UML)*. The notion of a distributed corporate information architecture mapped onto the organisation structure and controlled by the line remains a vision, 30 years after its conception. It is needed more than ever and the technology exists or could exist. But we have not seen a commercial interest in making it come true.

The idea of using the computer to augment the human intellect is still not main stream in spite of the pioneering work of Douglas Engelbart and others. A part of both Tender One and OOram was an authoring tool. When writing this paper, the author first tried Word® and then FrameMaker®. Both of them are merely automated typists. None of them helped the author in collecting material, organising it and polishing it. In desperation, he ended up using his old OOram tool.

Some people claim that development goes very quickly in the computer field. This is true for hardware, but not for software. The substance of information processing develops only slowly. But there is a great deal of vendor created noise and developer created complexity. We are still far from the simple, transparent and controllable information environments that we all really need.

8 Conclusion

The success of Autokon was to a large extent due to the five essential preconditions being satisfied; *market, organisation, finance, technical talent,* and *marketing talent*.

1. Ship construction changed from riveting to welding during WW 2. All major shipyards around the world were busy modernising to exploit the new technology.
2. The development was done in close and friendly co-operation between the researchers at SI and the end users in the line and on the shop floor at Stord. The Stord Yard in general and particularly key personnel in their lofting department were very open to new ideas and made essential contributions to the final result. (None of the researchers/developers were shipbuilders. It was later said that this was an advantage; they didn't understand that they had embarked on an impossible task).
3. Available technology was adequate. Computing power was sufficient and the random access secondary stores enabled a database-oriented architecture. The Facit carousel tape station ECM 64 semi-random access store was particularly important as was the large memory drum of the Univac 1107 where Autokon migrated after the Facit era. (The Autokon developers escaped from the endless spooling of magnetic tapes that hindered true progress in so many communities).
4. The designers/users at Stord Yard and the researchers/developers at SI were embedded in disjoint organisations and independently financed. This firmly put the two groups on an equal footing but joined by a common goal. The Aker Group wanted to become the world's most effective shipbuilders and SI wanted to create a truly great, innovative and commercially successful software product.
5. The project was securely rooted in the top-level management of the Aker Group; its CEO was an active president of the SIAG steering committee where priorities were set and budgets approved.
6. Marketing efforts were greatly helped through the Aker group being part of an extensive network of international shipbuilders.

The most important impact of the Nusse computer was probably the high tech milieu that was established around it and its research culture. A culture that was passed on to a stream of University master students who did their research in the Autokon milieu. This was clearly not the least significant result from the work.

From the start, work was highly oriented towards creating value for the end users in the short and long term. The research results were measured by their utility, not their academic acceptance. The focus was on comprehension, abstraction, design, and quality; the goal being to get it right the first time. (*"Any method that prevents the programmer writing code, is a good method"*). It also helped that initially; the same people were system architects, designers, coders, trainers of users, system operators, trouble-shooters, maintainers, and salesmen. The richness and viability of the many Autokon spin-offs illustrate the long-term value of broad, concerted and goal-directed research efforts.

It is worth noting that the Autokon project could probably not have happened today. The current fashion is to let end users dominate research projects. The nebulous Autokon project could not have survived a head on competition with real and urgent shipyard investment needs. On the other hand, the project could have failed if the research had been permitted to dominate; there were many interesting problems that could have diverted the project from its strictly utilitarian goals. The project achieved a delicate balance between these two forces; the developers focused sharply on the needs of the users, but they took the users' concrete requirements as symptoms of a general classes of problems that needed general solutions.

It is frustrating to observe that the Norwegian government's current research goals are linked to the expenditure on research rather than on its results.

"If you don't know where you want to go, you can't expect to get there".

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