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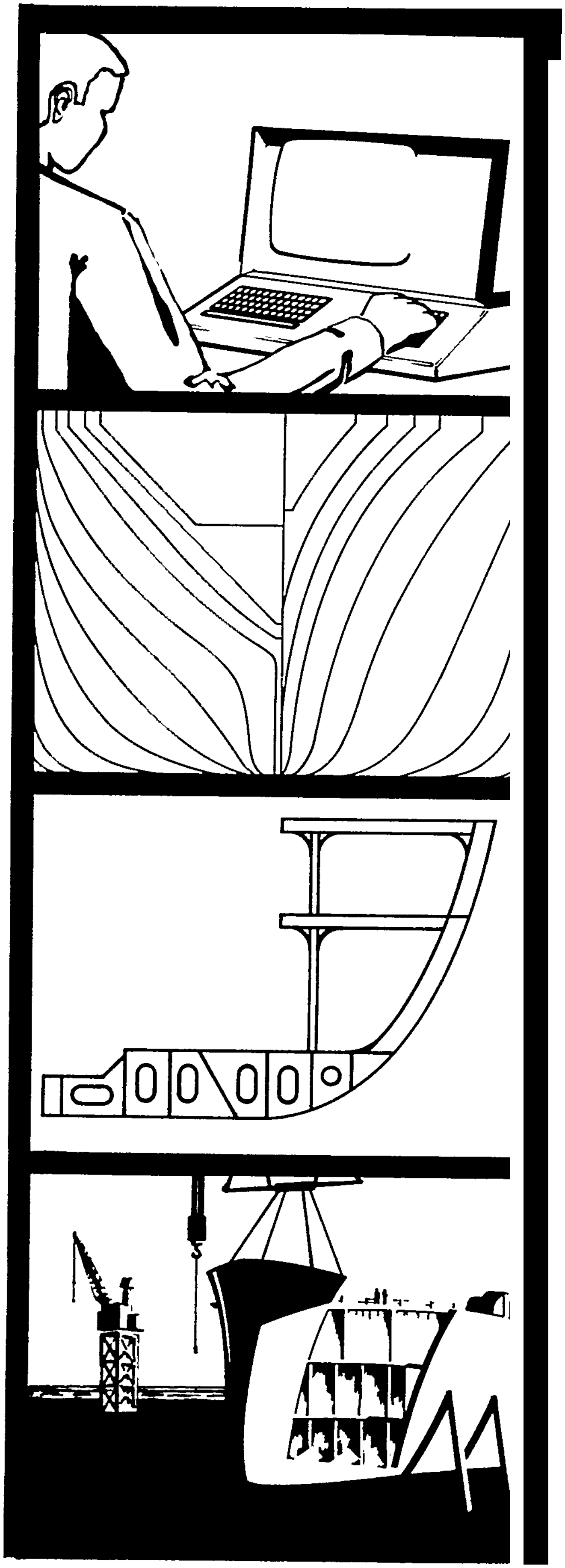

RESEARCH
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IN
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NEW SRS N/C SOFTWARE SYSTEMS DEVELOPMENTS

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INTRODUCTION

SIAG is the Norwegian abreviation for the Central Institute for Industrial Research (CIIR = SI) and the Aker Group (AG), a cooperation which has lasted for almost 20 years.

SRS is also a member of SIAG, acting as the exclusive marketing organization at the same time as participating in the development projects.

The SIAG cooperation is working with a number of development projects, of which the two major ones are AUTOKON and AUTOFIT. Both are sizeable projects with the same ultimate goal, to develop CAD systems for the 1980-ies. The projects have many things in common, even if they cover two different engineering fields, steel and piping. Therefore, this presentation consist of four parts:

1. Basic assumptions for the SIAG/CAD developments.
2. Description of Interactive AUTOKON
3. Description of AUTOFIT
4. Hardware considerations

of which the first and the last are common.

PRESENT SIAG-DEVELOPMENT

PART 1:

Basic assumptions

Presented by
P.F. Sorensen, SRS

1. THE SHIPYARD'S MARKET PLACE HAS CHANGED

It is only natural that the needs of the Aker Group have been and are of the greatest importance when it comes to the question of setting the systems requirements. The Aker Group's market place has changed dramatically over the last 5 years. From being Norways biggest shipbuilder, accounting for about half of the total tonnage delivered from Norwegian yards, shipbuilding is now reduced to less than 20% of the groups activity and will probably have less and less importance. 80% of the activities are now concerned with engineering, production and outfitting of structures for the North Sea oil exploration. These changes are not significant for the Aker Group otherwise than that Aker has managed to switch in time. The whole shipbuilding world is facing the same problems.

1.1 Diversification of products

In addition to ships a number of other products have grown in importance

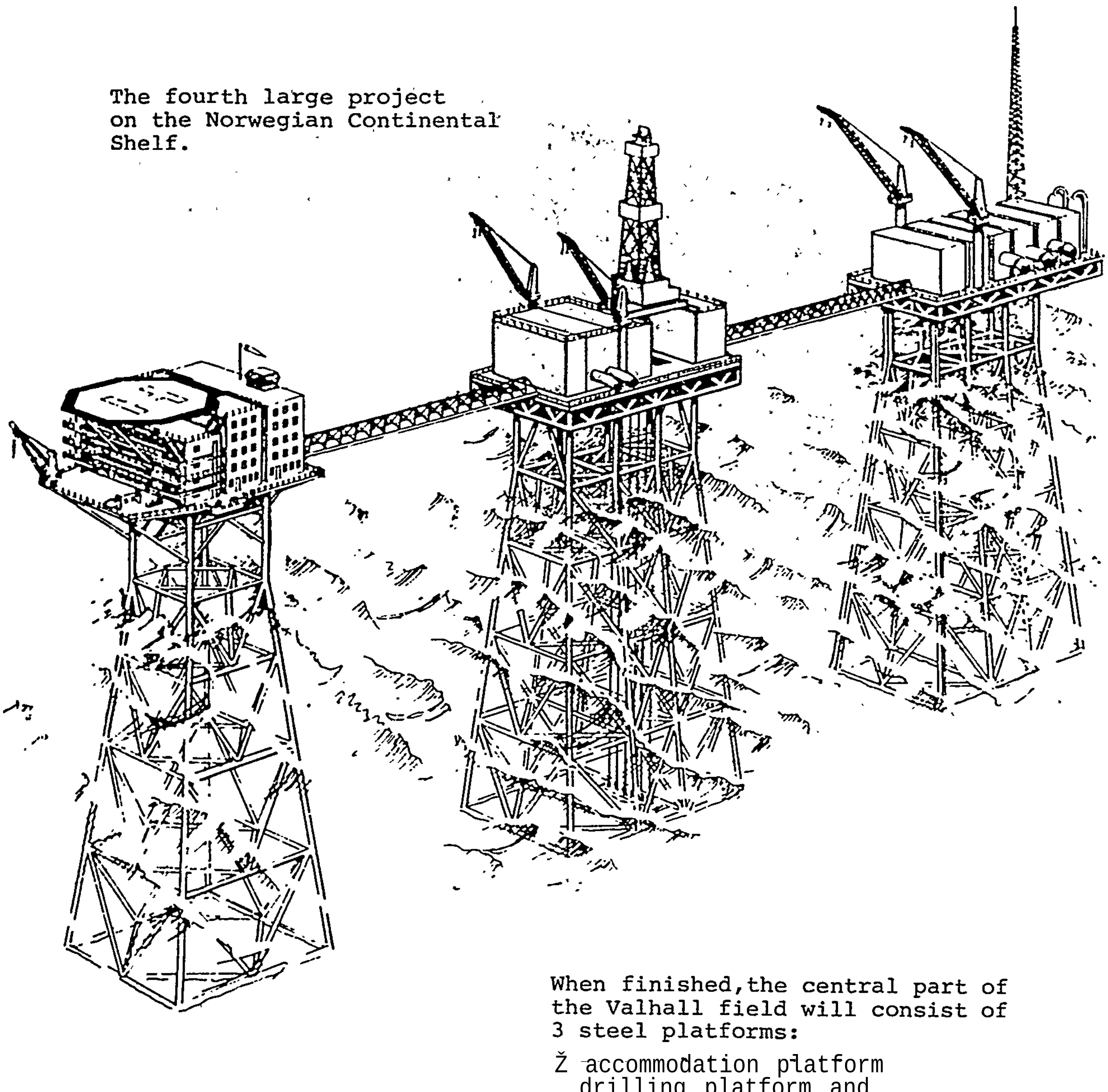
- Specialized offshore oilfield exploration and service vessels, frequently of the semi submersible platform type. Fig. 1.
- Offshore oil production facilities, "off shore cities" Fig. 2. Steel structures of the typical curved or flate panel type are replaced by pipe-truss structures, f.inst. for jackets.
- Concrete is substituting steel structures such as in the CONDEEP design. Fig. 3.
- These are just examples. Who knows what kind of products the present shipbuilder will have to cope with in the 1980-ies ?

1.2 The increased importance of outfitting

Some of the offshore products are a combination of a vessel and a process plant, a fixed or floating factory. Typical examples are the CONDEEP oil production platform and the Kværner's large project with gas liquidation plant and storage facilities. Fig. 4.

Valhall/Hod

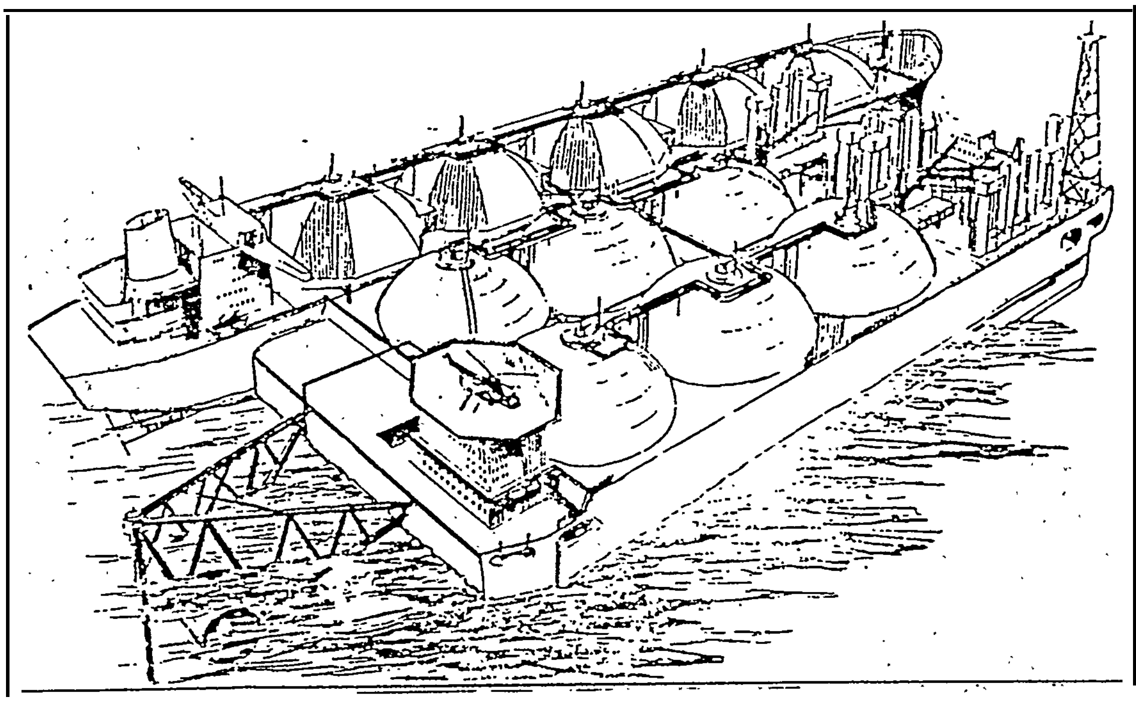
The fourth large project on the Norwegian Continental Shelf.



When finished, the central part of the Valhall field will consist of 3 steel platforms:

- accommodation platform
- drilling platform and
- production platform

Fig. 2



Floating gas liquidation plant and storage tanks. Behind the plant a gas carrier is loading

Fig. 4

Outfitting problems are increased by a factor 5 - 10 compared with convectional shipbuilding. Pi-ping systems, in particular, are of considerable size and complexity. The demand for efficient computer tools to handle piping engineering is therefore imminent.

1.3 The products are very complex prototypes

Little is left of the nice period of repetitive production of long series of ships. Not only are the product more complex in design, they are prototypes to a very large degree. There is less previous experience to build on. The frequency of design changes is very high. Both design and production engineering represent a tremendous task of coordination. Most problems occured are due to lack of proper product documentation which is either incorrect, inconsistent or missing.

1.4 Explosion in demand for documentation

Break downs in operation of the offshore structures may have enormous economical and environmental consequences. Extensive non destructive testing is required and puts heavy demands on administration of the quality control procedures and in particular on the documentation of results. Missing material certificates or inadequate reference of X-rays films to actual pieces of pipes or steel plates may cause costly replacements during production. This information is closely tied up with product itself.

Further the clients demand all kind--of reports as regarding the status of engineering and production. This was something quite different from the experience with shipowners, who normally did not care about the, builders procedures and methods, as long as the ship was delivered in time and according to specifications.

1.5 Lead time is short

Considering the fact that the products are complex prototypes, the lead time is much shorter than was the case with most ships.

Very heavy demands are put on “engineering” projects, detailed design documentation for prefabrication, shop assembly and field assembly. And not to forget materials supply!

Short lead time must be expected to be the rule rather than the exception in the future.

1.6 Product in focus

The shipbuilder is used to a kind of function oriented management, like a “production line” where similar engineering tasks on all products are “passing" the various engineering departments.

A much more product or project oriented management is demanded. In other words, the products is in the focus and all functions, either technical or administrative have to organize themselves, around the product.

The produtcts itself is the-source of all essential and necessary information for all functions supporting engineering and production.

1.7 More subcontracting

Due to the size and complexity of the projects we have seen examples where both engineering profabrication and assembly work have been farmed out to a number of companies spread all over the continent. It is evident that this puts some heavy demands for coordination on the main contractor.

What would be the main source of information to be able to control it ? First of all, proper products documentation.

These facts of life have some important bearing on what kind of computer aids we should look for, and they put some pretty heavy demands on systems development.

2. DEMANDS ON SYSTEMS DESIGN AND IMPLEMENTATION

If we look back on the AUTOKON development, the very fact that triggered it off, was the desire to feed a piece of work shop equipment with N/C burning tapes as efficiently as possible, The systems designed for the 1980-ies must incorporate quite substantially more and be radically more efficient than systems available in 1978.

2.1 High degree of products independence

This demand on systems design should be obvious from the previous section. Interactive AUTOKON will not be associated with stiffened "steel" panels only, but be equally applicable to any type of geometry and materials. AUTOFIT will be independent of purpose of piping systems: ship system, process plant systems for petro-chemical or chemical purposes. In AUTOFIT the goal is *even* higher, since the concept is basically general for analogueous out-fitting problems: piping, ducting, electrical.

2.2 Source for generation of product documentation

By tradition any product is implicitly described by its drawings. The drawings, tables and other documents represent the "database".

The same product (f.inst. a ship) may be documented in-just as many different ways as the number of yards building it, according to local needs and practices. And the same ship can be split into quite different prefabrication arid assembly units depending on local practice and facilities.

The nucleous of the system is therefore the computer based product model which represent the product "reality". The product documentation is basically reflections of this model in terms of composed layouts, presentation of different views, merging of drawings and tables etc., in other words, manipulated information with its origin in the product model.

2.3 Serve as document files (archives)

The computer based document file shall be the “original”. When the product model is modified the database “original” will be automatically updated, or at least the system shall advise on the consequences of the modifications. On the other hand, drawings may contain a variety of information which do not directly affect the product model itself. The advantage of having the “original” in the system rather than as a transparent paper in a cabinet drawer, is obvious. Technologically one is very close to solving the problem of using ordinary TV–screens to vizualize data bank contents, which may have a dramatic effect on distribution of documentation.

2.4 Serve as source of information in general

To be mentioned

- Analysis and calculations
- Other design and production engineering functions
- Materials supply
- Methods and planning
- Quality control
- Cost control
- Shop automation

In fact, the product model and document file comprise the very source of almost all information needed by any other function in engineering and manufacturing of the product.

In comparison with most technical systems of to-day, the potential “harvesting" effects are tremendous. The information system aspects are just as important as the “computer aided design” itself.

2.5 Excellent user communications are required

The above mentioned items are concerned with the properties of the information system as such. However, with to-days batch technology we would be very badly off when communicating with it. Therefore, on-line interaction is a necessity to provide proper communication between the user and the system. It concerns both interactive graphics and on-line selective information retrieval on alpha numeric terminals.

Frequenlty, we see interactive graphics evaluated more as a goal in itself, rather than as a means of communication with an information system.

2.6 High degree of hardware independence

In our development we are aiming-at separating what to do from how to do it. The first aspect of the information system is rather statical over time, while the other is dependent on the current computer technology available. A major objective is therefore to create an information system which comply with the needs of the user without forcing him into complete-hardware dependency.

Software portability should be considered important by any user, because he will have to face the rapidly changing developments in computer technology. For us and from the point of view of marketing portability is crucial. We are convinced that the wide distribution of AUTOKON is partly to be credited to the fact that the system was reasonably portable. portability is not granted free of charge, it must be deliberately built into the system during development.

2.7 Standardization of software components

In order to obtain the desired implementation independency the systems are made selfcontained with regard to such facilities as database software, picture file system, command processor, segmentation system, general picture graphics, system, etc. Most of these software components are of general-purpose nature. Apart from serving above needs, they also facilitates standardization, which again means lower system development costs and system maintenance costs.

3. THE INTEGRATED PRODUCT MODEL

One of the ways to meet the various demands imposed'on the system is the introduction of the product model. Since so much em– phssis is given to the product model, this section will be devoted to an elaboration of this concept.

3.1 The problem to be described

What is to be described in the model ? The products which are considered here can be viewed in many ways. If interested only in the funciional purpose of the product as a whole, certain performance parameters may be sufficient.

If interested in structural detail, it may be necessary to have an exact description of shape and position of the detail. Due to the enormous amount of detailed structure which may be present in the considered products, the representation in the database is essential for a successful system.

Also the functional relationships in the detailed structure and the way such details are put together to form larger logical units is essential and must be reflected by the logical description in a simple and efficient manner.

To the model which thus emerges must be added various user functions like the output of reports/drawigs, generation of meshes for finite element analysis, etc. Also to be considered is the efficient handling of numerous updates and changes which is so typical to the process.

3.2 Some functional requirements

0 It must be possible to communicate with the model inter- actively by means of information in drawings, text and tables.

0 The data must be available for new and possibly unforeseen applications. The data must be stored and structured in a tidy and "modular" manner which allows restructuring.

- o Description of the model must be possible even though exact or final parameters are not available. The same model must still be valid when final parameters shape has been determined.

- 0 The consequences of updatings must either be considered automatically or the user must be told where and what to update.

- o Redundant data should be avoided as much as passible. A consequence of this (which has more meaning) is that if we feature is to he changed this should mean only one logical update in the database even if consequences are numerous.

3.3 The integrated product model

The purpose of a CAD/CAM system is to solve one or more design or manufacturing problems. Consequently the total data base model must primarily reflect the requirements of all the relevant applications. However, existing applications change and new ones are added. This implies a need for a central description reflecting the product in a general way rather than any applications. This central product model is the common denominator to all applications? Ideally it is not effected by changes or additions in these.

Applications do exist, however, and must be appropriately integrated in the system. The different applications in a total system may communicate with the product model in a number of ways (fig. 5).

1. The application works on a common data description (central product model). This model contains all the relationships and other information needed.

2. The application derives its data from the model. The derivation may be performed through procedures (programs) which produces new data. If the procedure is considered a part of the model, then the model is said to be procedure oriented.

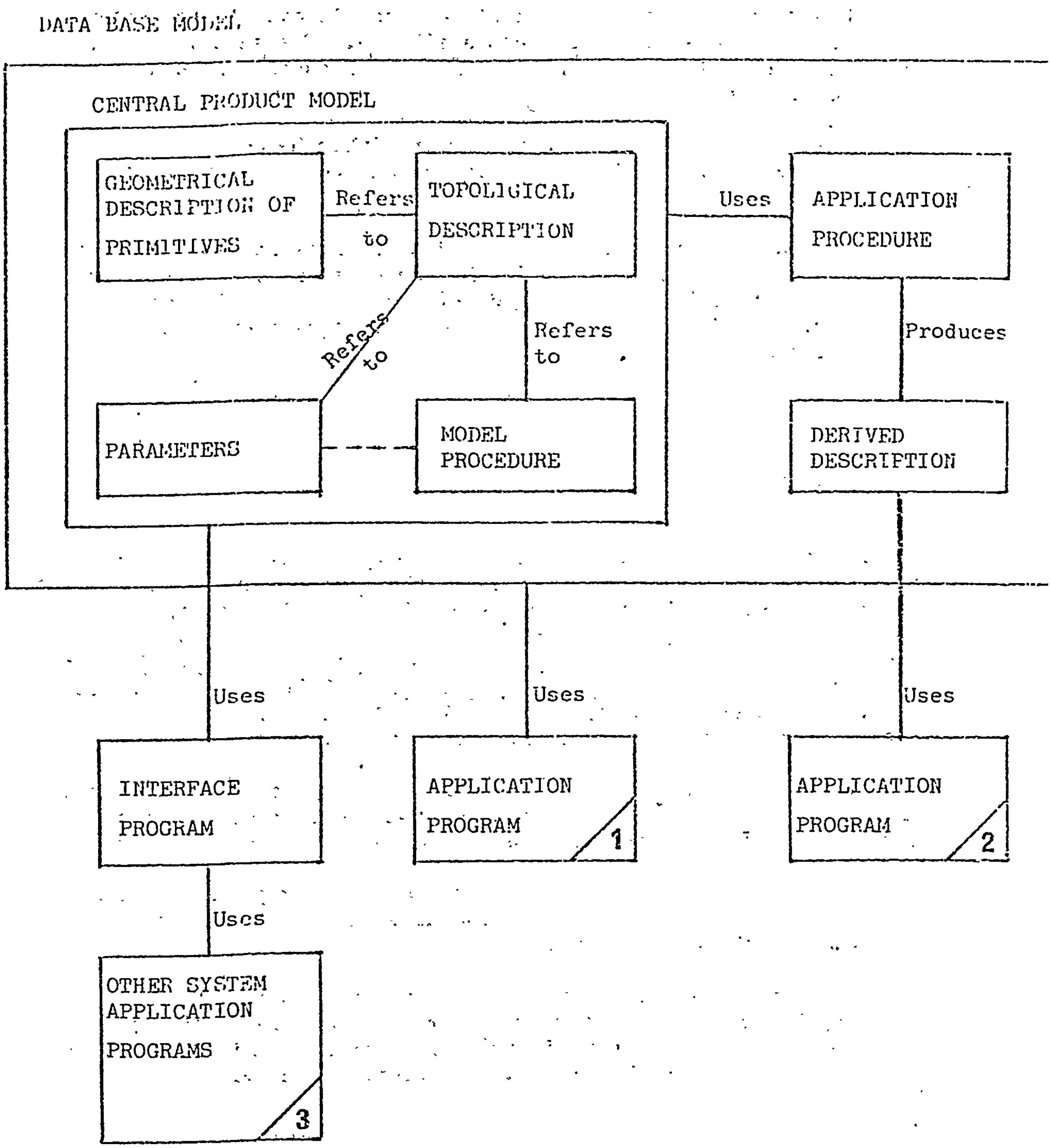


Fig. 5 How various applications may communicate with the product model.

3. Interface programs transform all relevant information to a suitable form which is used by the application. This solution results in several representations of the same data and hence consistency problems. It may, however, result in simpler data structures.

4. Data are derived manually from drawings, tables etc.

The product oriented model is the most static element in the overall database model.

3.4 The product model is change oriented

A common way of describing geometry in interactive graphics is by a number of closed or open planar polygons where each side of the polygon is described by referring to the endpoints. If any such point is displaced then all polygons involving that point will be changed as well. We wish to generalize this effect by using logical references for curves and surfaces as well as for points. The effects we wish to obtain is perhaps best illustrated by the following.

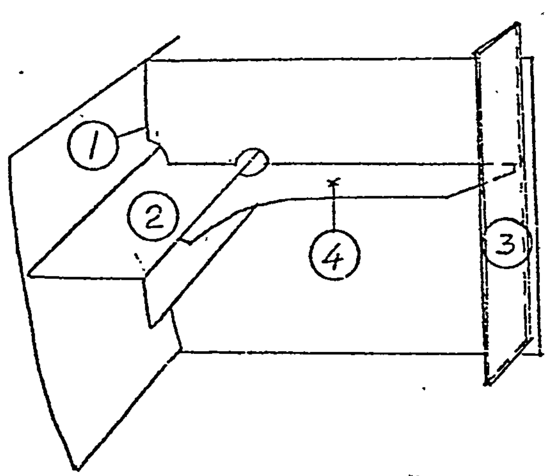


Fig. 6

In fig. 6 we have for example started off with a description of the shape of a ship hull. This hull may be defined in a variety of ways, but for the same of argument the representation may be a set of transverse frames (1) . The important point is that the longitudinal frame (2) and the flange of the web frame (3) is defined relative to the hull description. This means that primarily the data base contains a description of how (2) and (3) is derived from the hull description (1) for example by a reference to a parallel routine and the relevant parameters (parallel distance). Furthermore the bracket (4) is again defined relative to (2) and (3) . Note that even if the geometry has not yet been described, the other features may.

The purpose of the product model is to describe the product by identifying its functional entities and their relationships or "connection structures". These connection structures we refer to as the topology of the product. The topological description is separated from, but may refer to, the geometrical descriptions. In cases of geometrical changes the topological description refers to sufficient information to generate the new geometrical solution.

This approach has the following advantages:

Only's minimum of geomentrical data is needed to describe the structure (minimum of data redundancy). Thus it means less work in the initial definition of the product.

The descriptions of topology and geometry are separate and independent of each other which means that for a ship the internal structure may be defined prior to having defined the hull shape. More generally this allows flexibility as concerns the work sequence in a typical engineering design process (fig. 7).

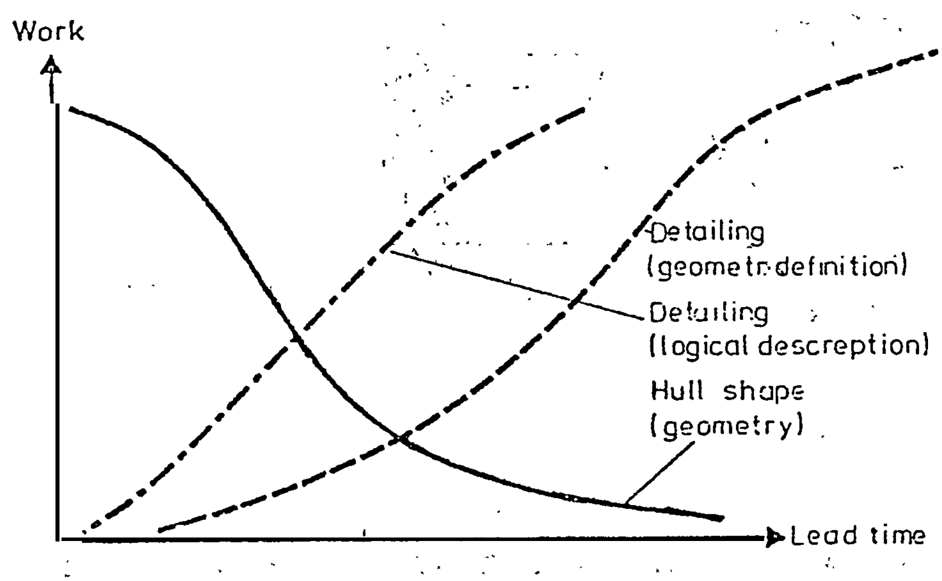


Fig. 7: Reduction in lead time.

All the geometric consequences of a change in scantling (the most typical change) will inherently be taken care of without additional changes to the data base. The ability to handle changes and updates is certainly a major problem area. The topological description should reduce this problem to a minimum giving a change oriented system.

Additional or alternative geometric representations are easily introduced. This is due to the fact that the major part of the product description is geometry independent and therefore does not change.

3.5 General layout of the database

At the top-level of database design, the system may be considered as consisting of two parts (see fig. 8).

1. Integrated product model:

   This part constitutes the internal model of the object (product, drilling rig, ship, production platform, jacket etc. or only part of these). Note how the "topological description" (TOPOLOGICAL UNITS) are separated from the parametric descriptions (SURFACE-, POINT-, CONTOUR UNITS) the former only referring to the latter.

2. Commiinications:'

   This part takes care of the communication with the central database and also contains the archives of the reports/ documents which have been made.

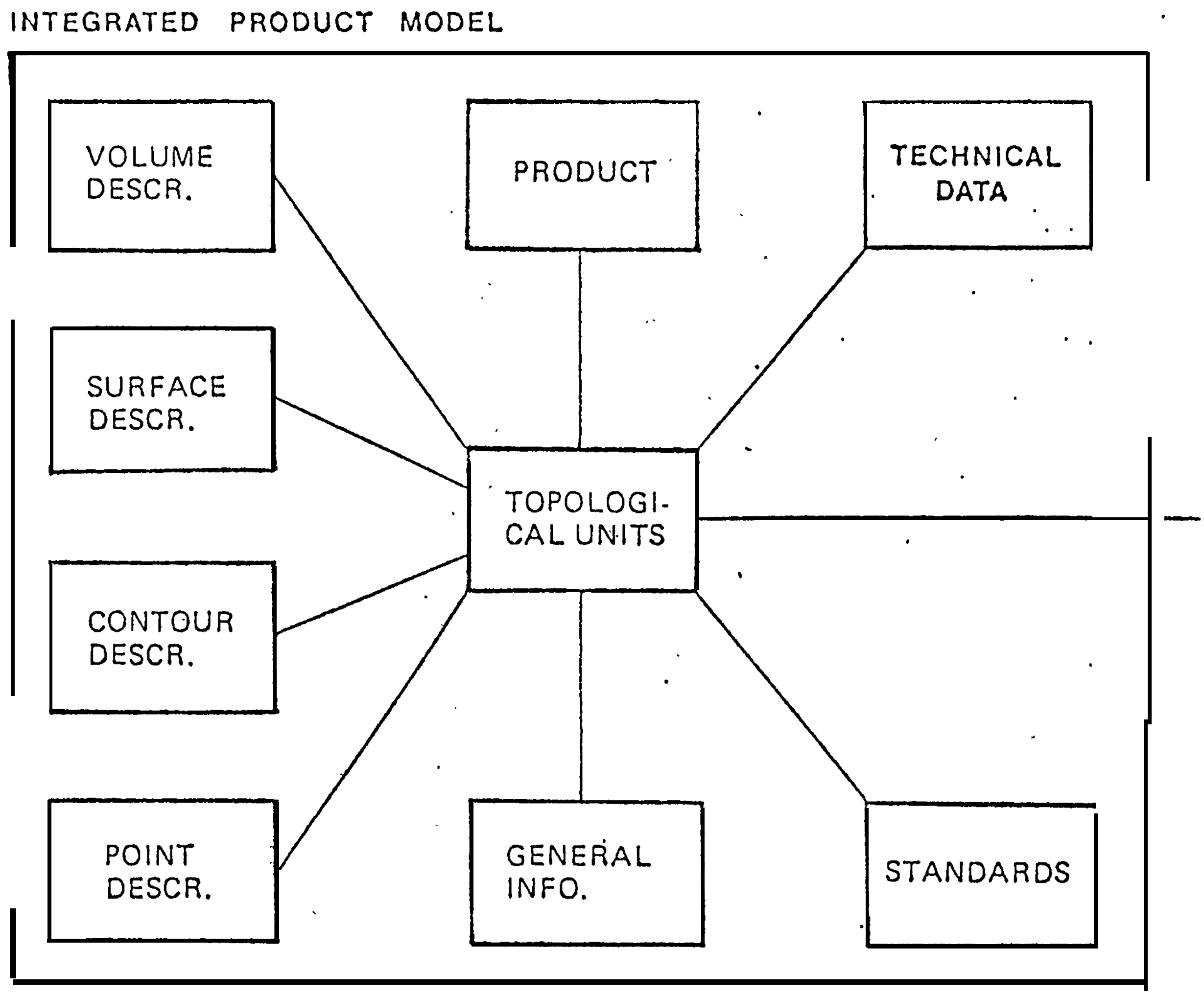


Fig. 8 THE COMMUNICATION DATA STRUCTURE

PRESENT SIAG-DEVELOPMENTS

PART 2

Interactive AUTOKON

presented by
P.F. Sørensen, SRS

FRESENT AUTOKON APPLICATION IN BATCH TECHNOLOGY

It is considered appropriate to give a summary on the present AUTOKON before elaborating on the new developments.

The existing AUUTOKON applications in batch-technology is based on the use of a set cf FORTRAN programs labelled AUTOKON-76 with a library of ALKON systems Norms. See fig. 1

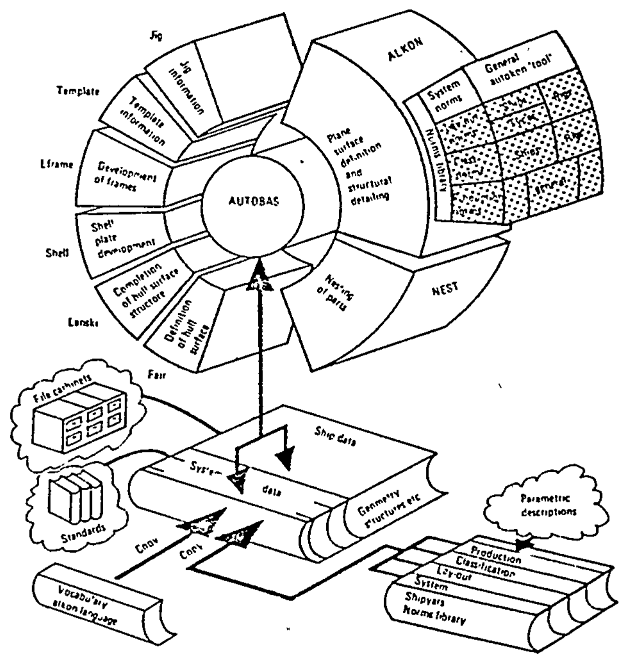


Fig. 1   AUTOKON information system

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The "shell structure" modules of AUTOKON-76 have proved to be equally usefull as design" and lofting tools. Actually, these tools do the same job, whether early or late in the process. The benefit to the designer is a matter of his attitude and willingness to use it in his work.

As concerns "internal structure", ALKON and the Systems Norms library may perform lofting in an efficiently way. However, extended use of ALKON in design and production preparation required an enhanced norms library.

A special norms library for extended use on $hips was developed in the Aker Group. This design and production norms library comprises "packages" for a number of purposes:

- Norms to establish data structures. These are general and we do believe in particular that the production phase data structure is a convention which may be used by all ALKON users. This structure provides the possibility to extract a number of information by drawing norms and list norms.

- Norms to describe surface and surface structures (plates and stiffening). These packages are mostly "function" and "geographically" oriented: Double bottom, web frames in engine room, etc. They have been run on several ship projects and have been modified for increased generality.

- Norms to describe types of codes (f.inst. material identification for plates and profiles) and various standards.

- Drawing norms for design and production drawings, either ordinary block drawings or levels .of drawings reflecting the assembly structure.

- List norms for generating various types of tabular information, stiffener lists, assembly lists, weight and center of gravity of blocks and sub-assemblies, etc.

The above norm packages mdke,'of course, frequent use of the basic "System Norms" in possession of all ALKON users.

The integrated design and production norm makes it justified-to classify AUTOKON-76 an "information system", .even if the batch technology leaves a lot to be desired as regards communication with the database.

Fig. 2 gives a schematic outline of the various norm packages and their place in the downstream process.

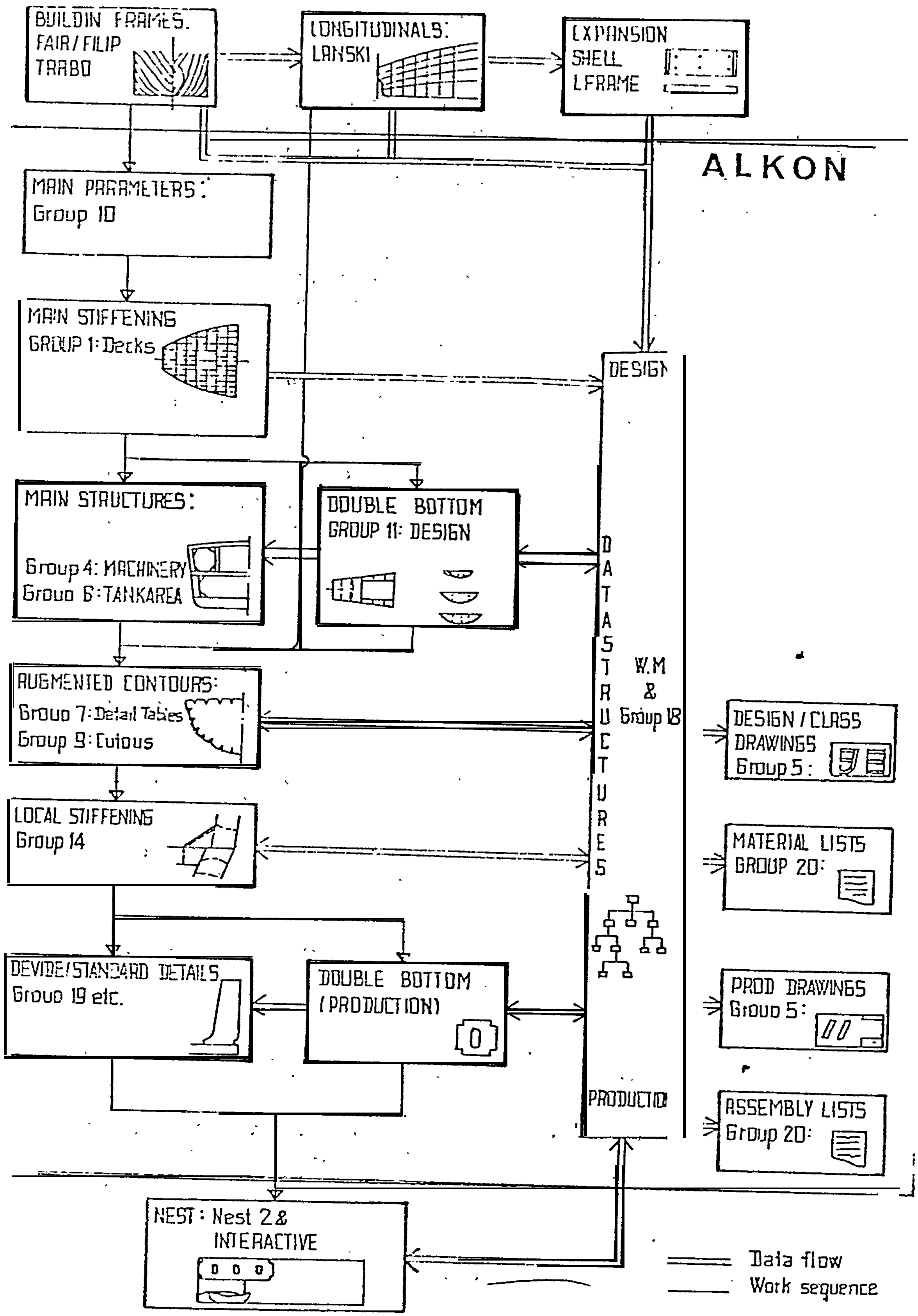


Fig. 2. Structural detailing by AUTOKON.
Schematic flow-diagram showing use of the various norm "packages" in the down stream process.

It must be admitted that these enchanced norms libraries did not create a break through of ALKON in design.

First of all, the batch technology is not very suitable for convincing the designer that the computer can beat him in making a drawing. Since he has to.face changes, the computer would rather delay him than speed' up his work. He is not willing to accept that even if somebody down stream obviously would benefit bv reduced work load and higher accuracy.

' However, notwithstanding batch deficiencies, a great deal of the short comings came from the way ALKON was used, and not from basic limitation in ALKON itself, since it is probably one of the most powerfull geometry compilers available.

- It was not fully apprehended that a very thorough system analysis of the "design process, "formalized procedures and extensive standardization work were fundamental prior to coding an "hierarchy of ALKON norms to cope with design:

- It was not fully understood that norms development of this magnitude was genuine systems development, and that the basic requirements as to user specifications, systems design, systems programming and documentation were valid. No matter whether the programming language,was ALKON.

- The efforts involved and demands on qualifications of participants were underestimated.

- Lack of time for creating, sufficient "generality" because of pressure from production schedules.

- When the norms were ready, the majority of Aker Group ship contracts were cancelled and efforts turned towards offshore structures.

In spite of above experience,. the norms library has proved useful for the Aker Group. both"for ships and" semi-submersibles.

The power and felxibility ,of.ALKON has really been proved in connection with' unusual constructions such as pipe-trusses (jackets).

At the Aker Verdal yard they managed to increase work preparaticn efficiency considerably by creating a special norms library for jacket design, fig. 3.

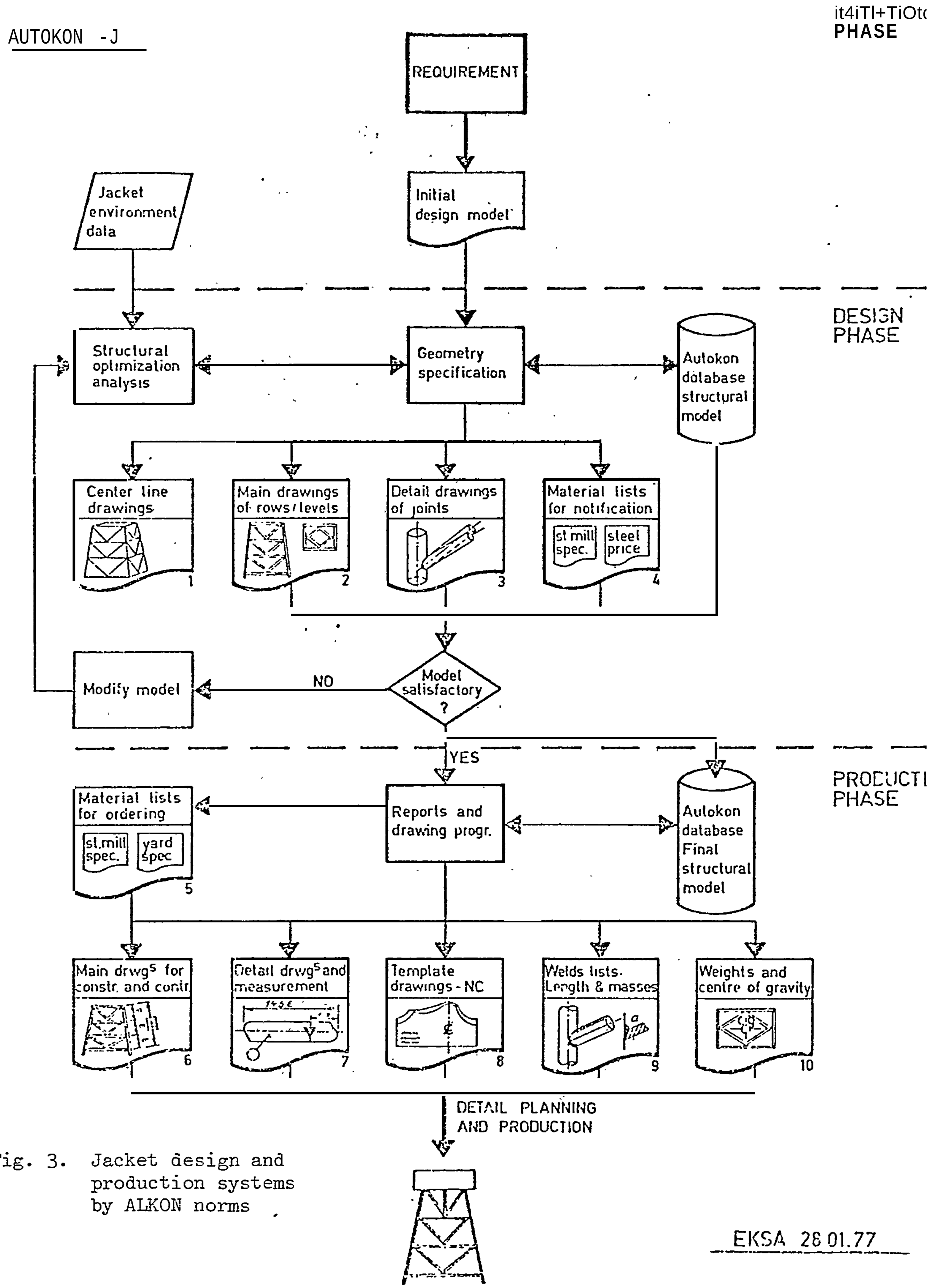


Fig. 3. Jacket design and production systems by ALKON norms

After a few weeks the first norm were actually used in production preparation. The norm which generates the template for the cutting of truss connections (activity 8) produces a template in 20 - 30 minutes. Manually a good craftsman" would manage 2 to 3 templates a day.

The accuracy obtained using a numerical method was far better and a substantial saving and better product quality was registered. Let us just mention that in 12 leg Jacket which has been built there were 560 such templates. The tubes in the Jacket had a diameter of up to 1.5 meters and a plate thickness of up to 70 millimeters. The actual truss-connections may be very complex often with tubes intersecting eccentrically.

2. INTERFACING THE PRESENT AND FUTURE AUTOKON

3 years ago it was decided to develop a new AUTOKON system for the 1980-ies. Based on the requirements previously set forth and the knowledge of short comings .of present AUTOKON, it is obvious that Interactive AUTOKON had to be established on an entirely new concept.

The development project started with AUTONEST, the new operational interactive nesting system, and has another 3 - 4 years to go. However, since short term results was demanded, the goal is to provide the user with the best total system throughout the development period until the present AUTOKON is finally replaced

Hence, it is not the intention to throw the present AUTOKON overboard. On the contrary it represents a powerfull and flexible tool that has reached a remarkably high operational reliability.

Our development policy is to get short term results which can extend the present. AUTOKON usage at the same time as being integrated parts of the new system.

We believe this development policy is to the.advantage of all present AUTOKON-76 users, since it will allow them to change gradually towards the full Interactive AUTOKON if desired.

3. INTERACTIVE AUTOKON (IA)

Fig. 4 is a description of IA in terms of functions and/or applications to be covered. The figure reflects the demands on modern technical information system previously mentioned and demonstrates the central position of the product model as a source of information. In fact, the figure is valid for all technical information systems covering different engineering fields (steel, piping, electrical, etc.)

It may be of interest to compare these functions with the modules of AUTOKON-76. It should be kept in mind that all functions are based on use of interactive graphics, hence this is not particelarly mentioned under each item.

Product model building.

This function is perhaps the most vital since it is the beginning of the process. Model building incorporates separate topological and geometrical description as well as data on functional requirements, material properties, ete. The product model includes both a design oriented (functional) structure and a production oriented structure. A particular part belongs to deck A at the same time being included in subassembly B.

Compared to AUTOKON-76 this function includes FAIR, LANSKI, SHELL, ALKON and in partiicular the enhanced norms Library.

Product documentation

This function offer powerfull facilities for verification and manipulation of product in informationin terms of drawings, tables, etc.. It means a significant diference from the batch tehnology, which is rather inflexible as regards composition, presentations etc. other than "programmed". It represents the "draftsman" and is really a reflection of the fact that there are many ways to visualize and verify a Product.

In AUTOKON-76 the drawing/printing functions are found inherence in all program modules; and in the enchanced norms library.

In IA this functidn is more a "general drafting tool" which also have the responsibility to administrate the document file.

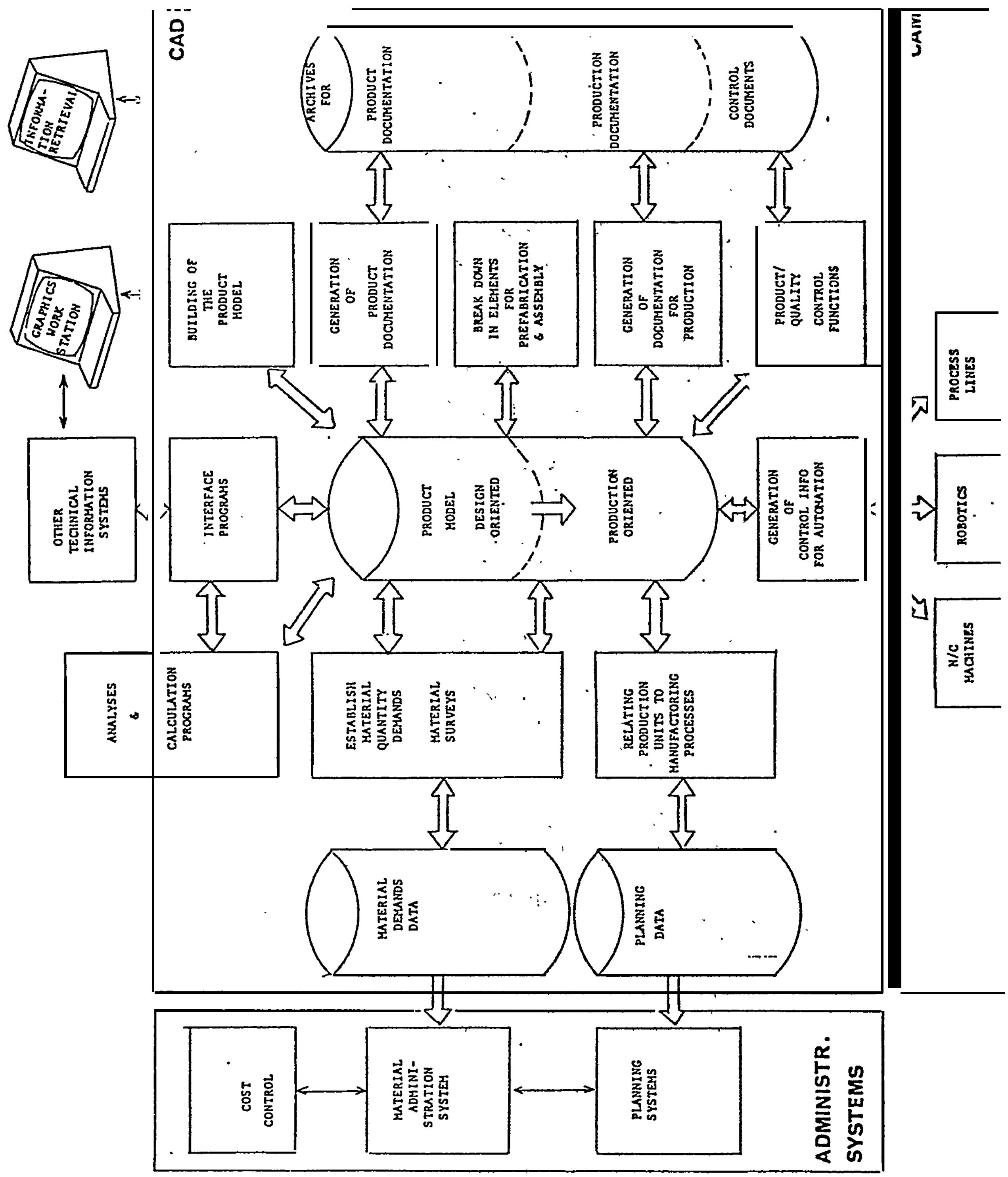


Fig. 4. Interactive AUTOKON, outline of main functions

3.3 Break down of production manufacturing elements

Starting from the design product model, this process will be more or less automatic. The efforts cbnsumed will be drastically reduced compared with traditional "part coding" which will almist disappear.

Based on this production oriented product model, generation and manipulation of work shop documentation will be made in the same way and by the same tools as in 3.2.

Comparing with AUTOKON-76; this function incorporate features found in the programs LANSKI, 0SHELL, LFRAME, TEMPLATE, JIG, ALKON and.NEST.

3.4 Product/quality control functions

Such facilities are non–existent in present AUTOKON-76.

The new functions are generally concerned with providing special drawings convenient for control and for establishing "as built'" information+ The second major objective is to tie-up all kind of testing and certificate data'to the product model and admin~-strate the cohtrol documentation.

3.5" Generation of control info for ,shop automation

This function is"the, link to CAM. Since the product model contains all information regarding both finished parts and finished product, it is a matter of post processing such data to control information.

More important is the fact that the product model contains infcrma-tion to control robots f.inst. *welding* robots. The potential exists for sibilating welding procedures.

In this respect IA opens up for a wide range of CAM applications, compared to AUTOKON-76, which is limited to N/C data in SHELL and NEST .

3.6 Material demands

AUTOKON-76 offers little in this respect, especially in early stage for material ordering unless the enhanced norm library is used. In this respect IA will mean a great step forward. This function will maintain a full 1:1 correspondance between engineering and material status, keeping track of consequences of design changes on materials specification vice versa. A variety of material summaries will be available and the material demand file is the source of information for the material administration system.

3.7 Relating product units to manufacturing

This function will provide facilities for calculations for processing times (cutting; welding etc.) and for relating parts and assemblies to shop equipment and production flow to ease production planning and control.. Of even more potential value is the possibility of interactive simulation to investigate production methods.

3.8 Interface to calculation and analyses programs

Typical examples are hydrostatics" hydrodynamics, structural analyses. These programs may either be inteegrated directly with the product model (f.inst. hydrostatics) or work on derived (simplified) design models, such as, in the case of generating meshes for finite elements calculations.

3.9 Communication with other technical systems

The most typical example is the need for structural information as "background" when doing piping layout. Or vice versa, the piping information system will provide exact position of all pipe penetrations in structures.

The outline of functions 31. - 3.9 above is equally valid for other technical information- systems..

4. BRIEF DESCRIPTION OF INTERACTIVE AUTOKON "MODULES"

4.1 General on terminology"

In AUTOKON-.76 a module is a program, performing a well defined task. Tne module structure is rather rigid and is self contained with output **routines** .

In the previous section the 1A functions were briefly described. A function may contain a number of applications or procedures which make up the totality of jobs or tasks either from an organizational point of view or because it is a convenient and natural way to group tasks.

Example: Material take-off" and making bill of materials for steel plates and bars.

A certain procedure may be required and incorporated in different responsibilities at different points of time.

F.inst., the interactive nesting system AUTONEST cotains 3 clearly distinguishible and (from a systems point of view) separate phases: preparation, lay-out (nesting) and cut/mark sequencing. Together these,3 procedures cover the total task to complete nesting as a loft function with the ultimate' goal to generate a N/C tape.

On the other hand, the lay-out (nesting) procedure should be available to the material take-off' man who is working several months earlier than the loftsman. In other words, the same procedure may appear in different functions. A procedure may be small or large in terms of EDP programs. The basic level is an action routine governed by commands.

An efficient command processor is avaiiable to link,together action routines to higher level procedures, procedures organized into tasks and tasks organized into functions.

From a systems point of view, therefore, IA must be regarded as a tool kit, a big library of basic tools (action routines) which may be organized as described above.

The "user manual" as we know it, will be reflecting how to Perform a task by means of a particular collection of action routines. The command processor allows the user to switch quickly from one procedure to another, even if he may see each procedure as "fixed".

Therefore, a module does not have the same meaning in IA as in AUTOKON-76 . However, certain names have been selected to express functions as a total or to signify procedures or applications as part of functions. These names may change, so may also the "contents" relative to the name.

Due to the relatively long term period of the IA development, the specifications are not of equal degree of detail, depending on the priority given to them.

4.2 *Names of* functions and applications

Fig. 5 is the.previous.fig. 4 supplied with names presently given to, either functions or. procedures/applications in IA.

The main functions are covered by

AUTOMODL	Design and production oriented model building including break down of product structure for prefabrication and assembly purpose.
AUTODRAW	General drafting tool for visualization of product model and for generation of design and production documentation,
AUTOCONT	Serving product/quality control functions
AUTOPROD	Providing link between CAD and CAM. Generation control information for shop,automation.
AUTOPLAN	Relating product units to manufacturing lines and processes.
AUTOSPEC	Serving the material take-off function

Within the functions fig. 5 shows the following procedures or applications , with a circumscribed name:

AUTOPART	The "bottom level" of AUTOMODL, providing a subset for interactively generating parts or dividing or modifying ALKON parts from AUTOKON--76.
AUTONEST	Interactive parts nesting generating N/C tapes for nested sheets.
AUTODRAW(S)	Subset of AUTODRAW intended for generation and manipulation of shopdrawings with a short term goal to use AUTOKON-76 data.

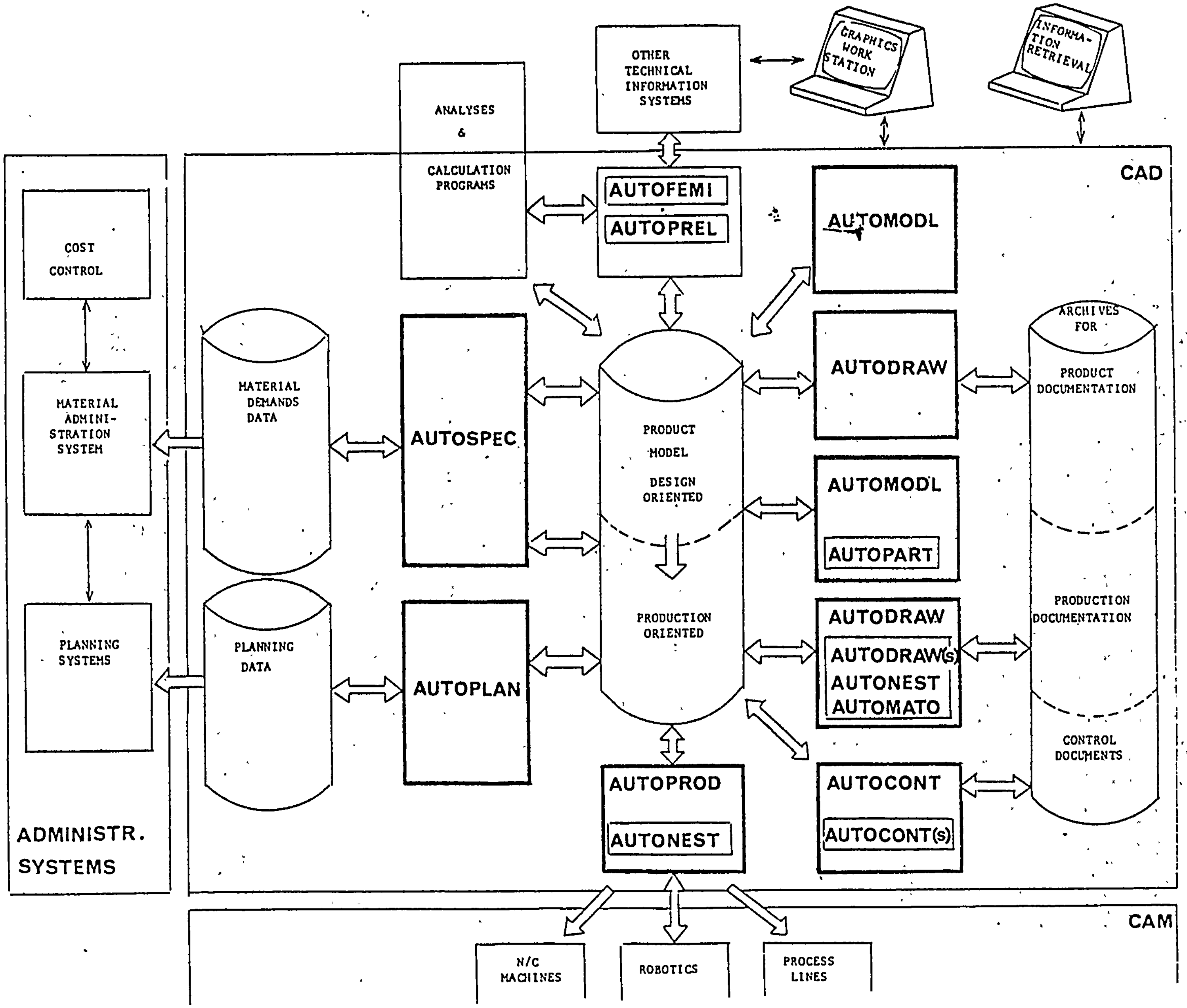


Fig. 5. Interactive AUTOKON, names of functions and applications

AUTOMATO — Subset of AUTODRAW to generate and edit various kinds of shop drawings for collar plates, marking of stiffeners, stiffener lists, etc. To some extent AUTOMATO will serve material take off function also.

AUTOCONT(S) — Subset with the limited objective of providing special control drawings for follow-up during construction.

AUTOPART, AUTONEST, AUTODRAW(S), AUTOMATO and AUTOCONT(S), represent the short term results of the IA developments.

By communication with the AUTOKON-76 database, they provide effficient interactive tools to manipulate A-76 data in a way that cannot be done within A-76 itself. This connection is indicated in fig. 6. They assume all "shell modules" of A-76 to be used., Further, the more extensively ALKON and norms libraries are used to build up the structure (the A-76 product model), the more information is available for further manipulation by the interactive procedures.

At the same time, as already pointed out, the same procedures are subsets of the final IA system, which should be seen from fig. 7.

In this way, the development policy expressed in section 3 is implemented by offering the AUTOKON user the best total system throughout the development period. These short term "results efficiently attack the product-ion preparation area, which account for some 50% of the engineering hours in handling of steel structures.

In addition to above mentioned procedures, fig. 5 do also include 2 interface programs to analysis, programs.

AUTOPREL : Making the IA product model available for a net PRELIKON system, planned to be developed in cooperation between SIAG and the other Norwegian parties.

AUTOFEMI : Generating a derived design model for providing meshes to finite element calculations.

In the following figures some of the above mentiofied functions or applications are briefly outlined in a simple, pictorial form which hopefully is self-explanatory, see fig. 8, and ***succeeding figures..***

However, as regards AUTONEST, AUTOPART and AUTODRAW, more details are given below.

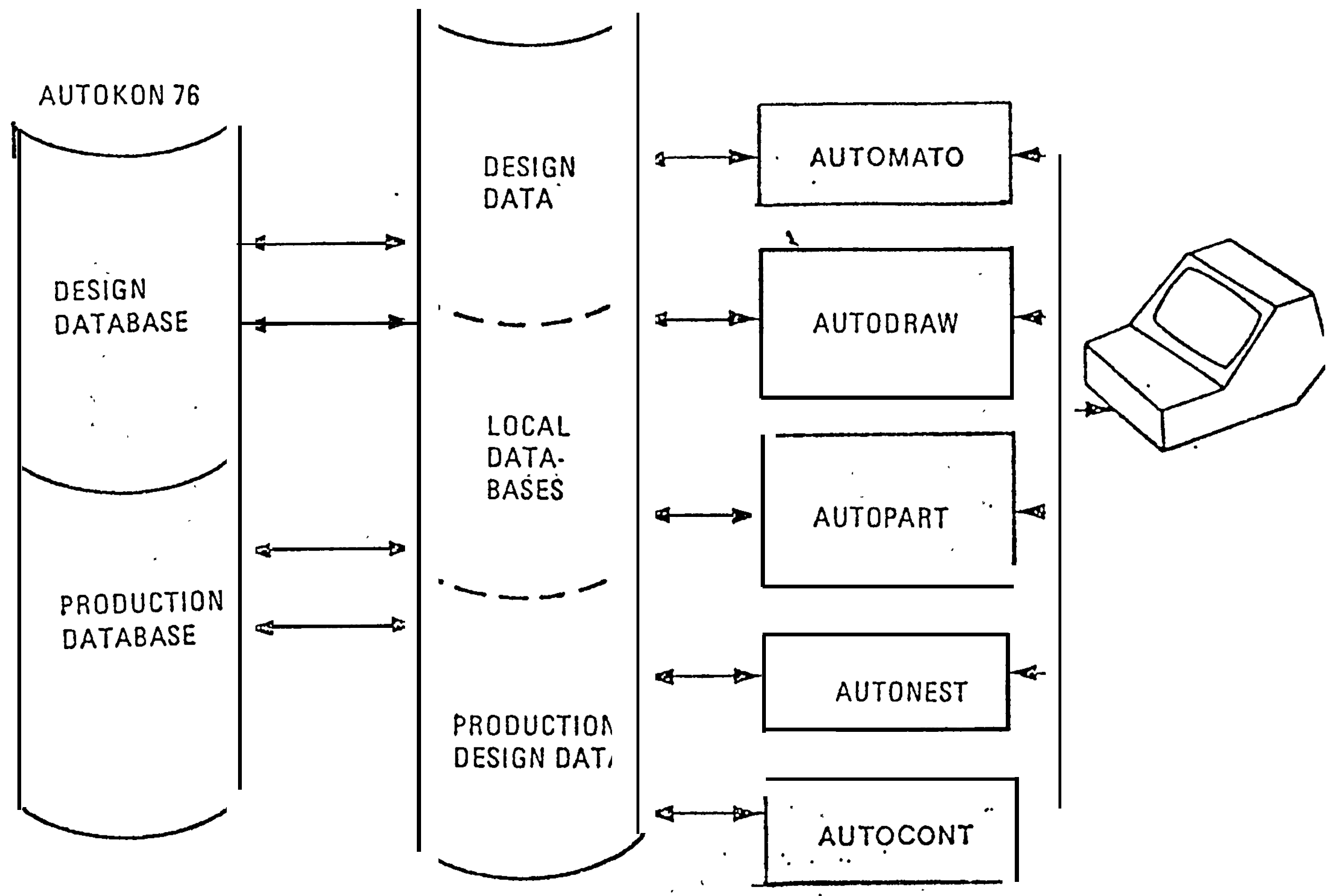


Fig. 6. Communications between AUTOKON-76 and certain applications in Ineractive AUTOKON

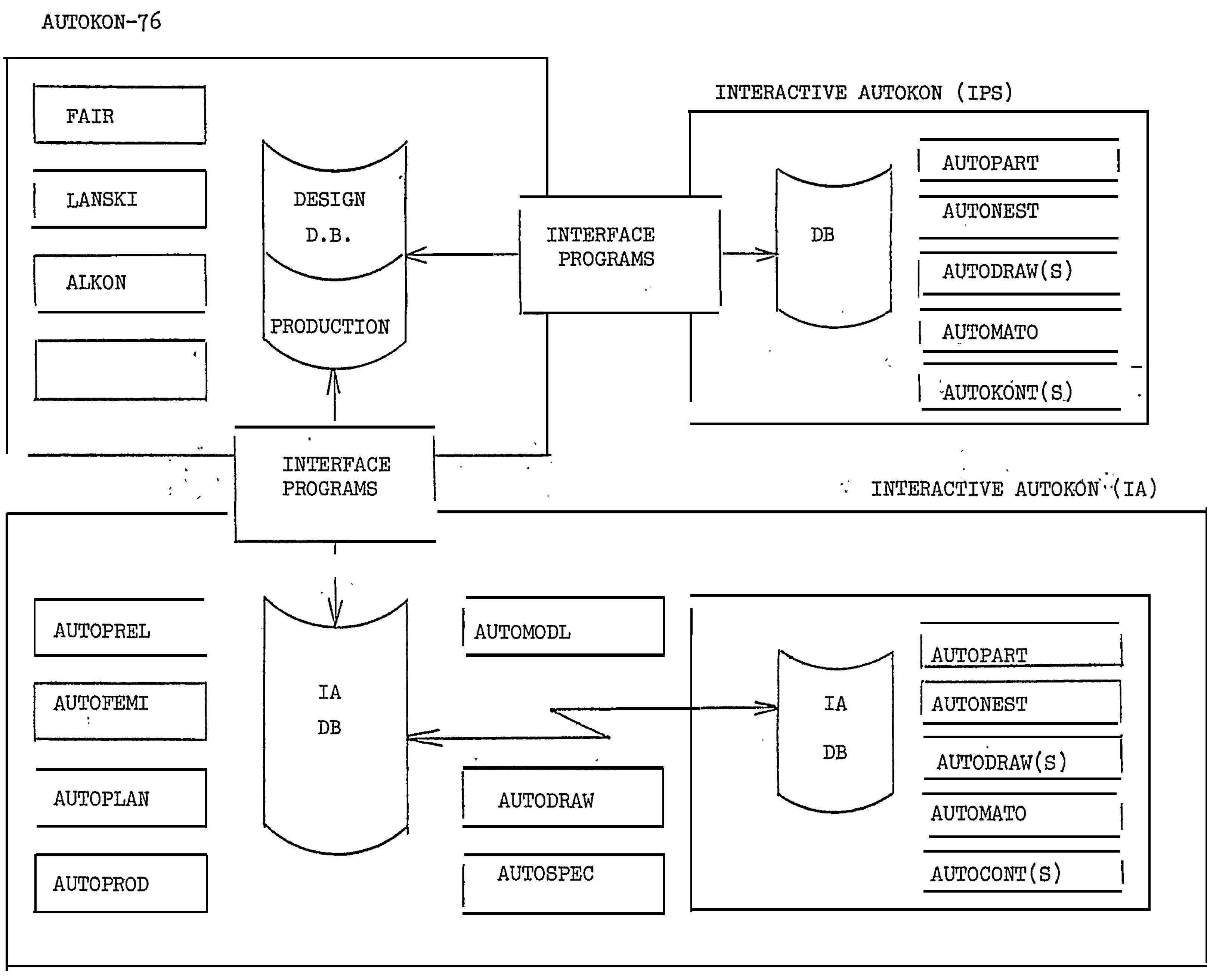


Fig. 7. AUTOKON-76 linked to interactive AUTOKON applications from ongoing developments

4.3 AUTONEST

This application is briefly described in the attached brochure. AUTONEST has been in operation for more than one year in Aker and in Verolme Rozenburg yard in Holland. We beleive it passed the acid test at Verolme and we quote from the paper given at the AUC-78 meeting (they are using 2 screens simultaneously):

> "Figures about savings in time and money, comparing batch and interactive versions, are very difficult to caluculate. VDSM traditionally pays very much attention to nested formats; Cutting combination, use of more torches, heat distortion and edge preparation does influence the time needed for the nesting procedure; it's our yard-policy, which has to be followed. Performing this sometimes elaborative way of nesting interactively did show a substantional reduction of manhours and calendertime, even in spite of all the problems which have been mentioned.
>
> Roughly, using 1 - 2 manhours, in 2 - 3 days for a plate filled with 4 - 12 parts in batch, now interactively 3 - 5 plates of this kind can be done in about 1 hour. (Max. performance 12 formats in 1 hour).
>
> Additionally, one format filled with 67 parts, some of these with inner contour, did take slightly more than half a day, against 2 - 3 days in the old way."

AUTONEST operational on a NORD 10/S computer with a minimum core requirement of 64 K words (16 bits).

4.4 AUTOPART

As already mentioned, AUTOPART is a subset of AUTOMODL, with the following features included.

Basic part coding:

- o Basic geometrical definition (SL, CIR, etc.)
- o Defining and referring to predefined contours
- o Treating standards (cutout, holes, etc.)

Advanced part coding:

- o Split contours
- o Editing contours
- o Generate and refer to parallel contours
- o Divide surface units (parts)

Model building

o Definition of design and production units.

In fact AUTOPART may be considered also as a stand alone part coding system just as ALKON basic.

4.5 AUTODRAW

The purpose of AUTODRAW is to provide to following facilities.

a. Verification of:

- o Contours
- o Tables
- o Text

b. Generation of drawings:

- o "Composition"-lay-out
- o Completion of drawings with

  Text
  Symbols
  Dimension lines
  Identifications/references
  Applying drawing "standards"

- o Generate other veiws

  Orthogonal
  Perspective
  Axionometric
  Isometric
  Removal of hidden lines

c. Build and administrate the documentation file:

The subset of AUTODRAW will include a), parts og b) and c) as far as shopdrawings are concerned.

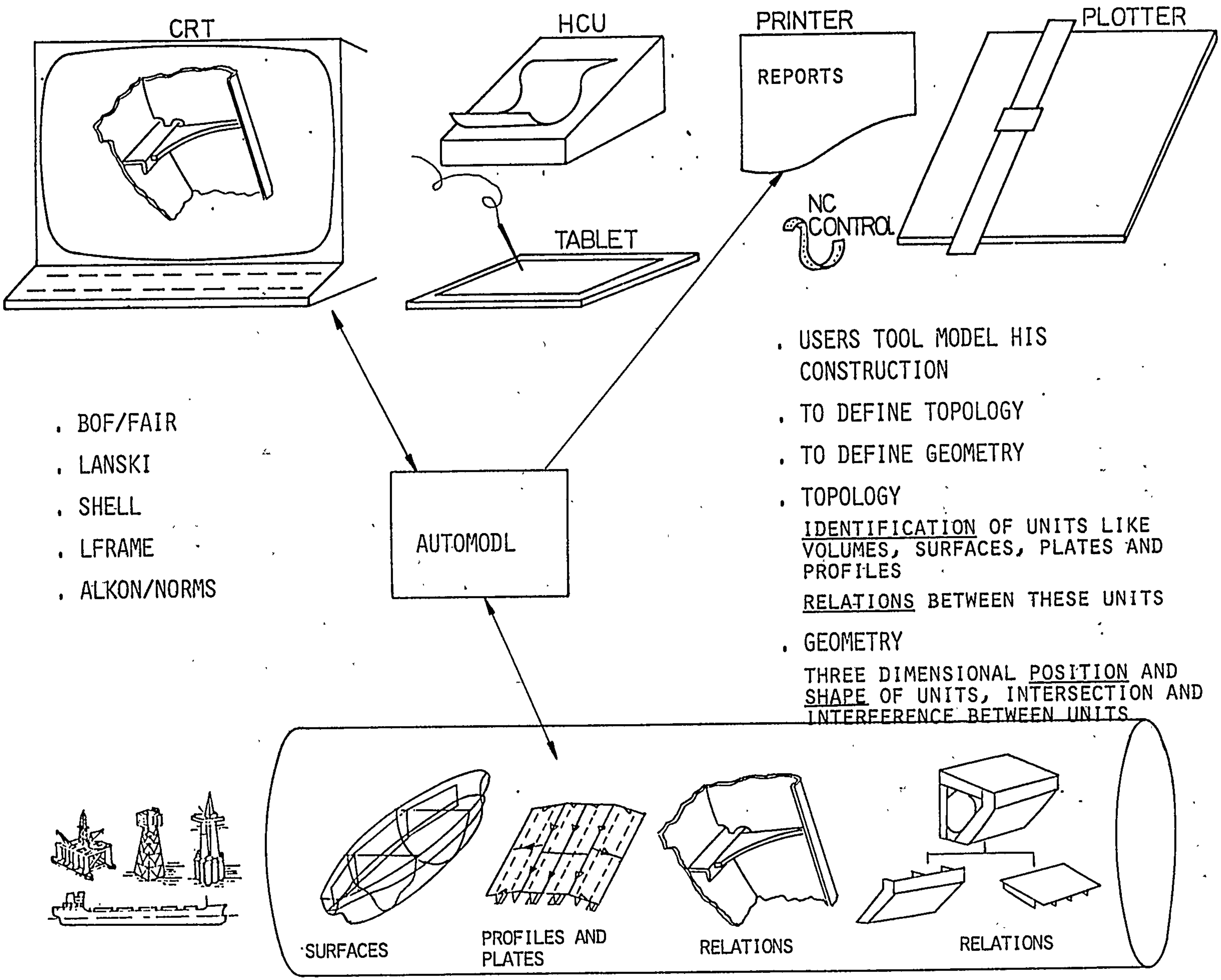

CRT
HCU
PRINTER
REPORTS
PLOTTER
NC CONTROL
TABLET
. BOF/FAIR
. LANSKI
. SHELL
. LFRAME
. ALKON/NORMS
AUTOMODL
. USERS TOOL MODEL HIS CONSTRUCTION
. TO DEFINE TOPOLOGY
. TO DEFINE GEOMETRY
. TOPOLOGY
IDENTIFICATION OF UNITS LIKE VOLUMES, SURFACES, PLATES AND PROFILES
RELATIONS BETWEEN THESE UNITS
. GEOMETRY
THREE DIMENSIONAL POSITION AND SHAPE OF UNITS, INTERSECTION AND INTERFERENCE BETWEEN UNITS
SURFACES
PROFILES AND PLATES
RELATIONS
RELATIONS

Fig. 8.

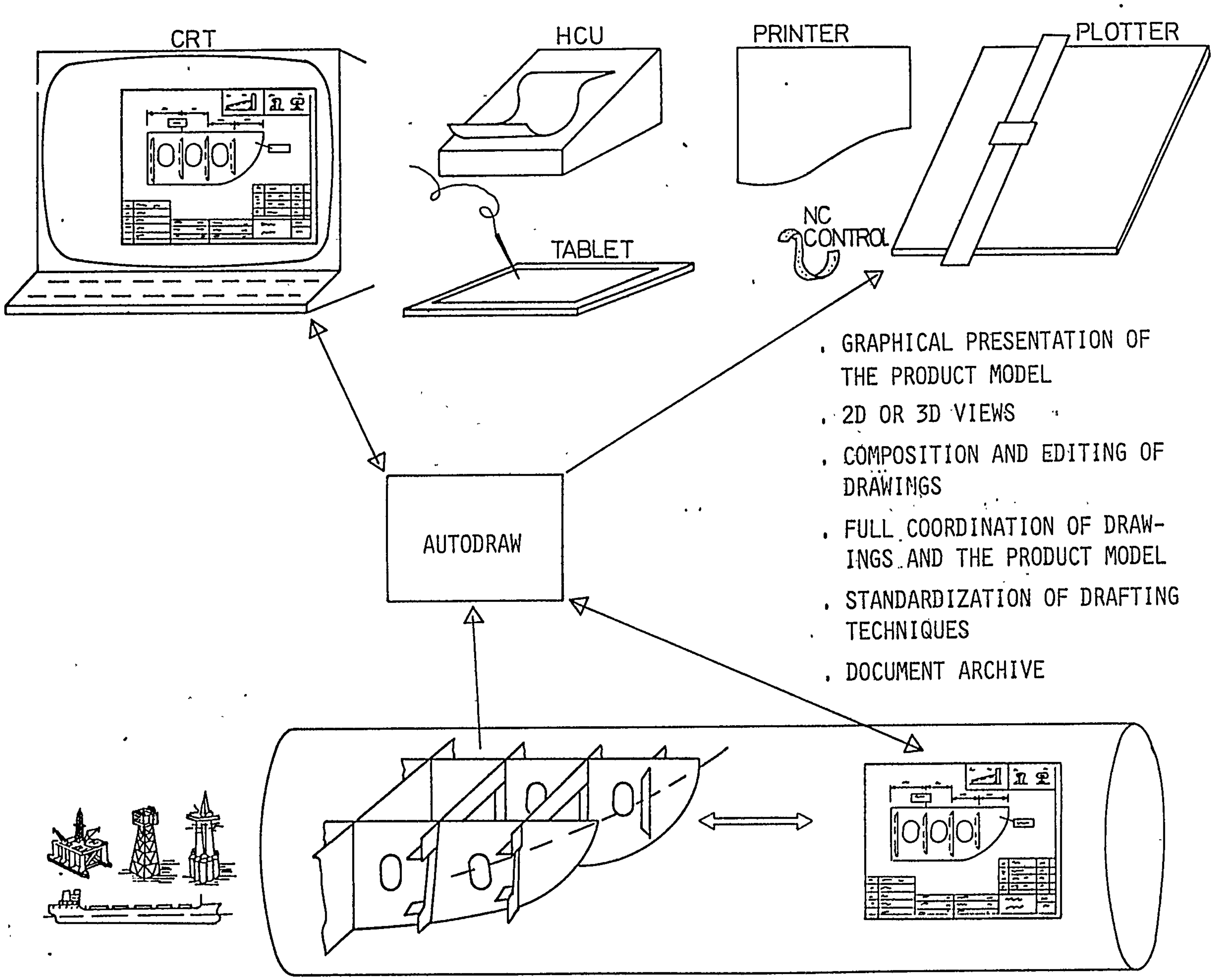
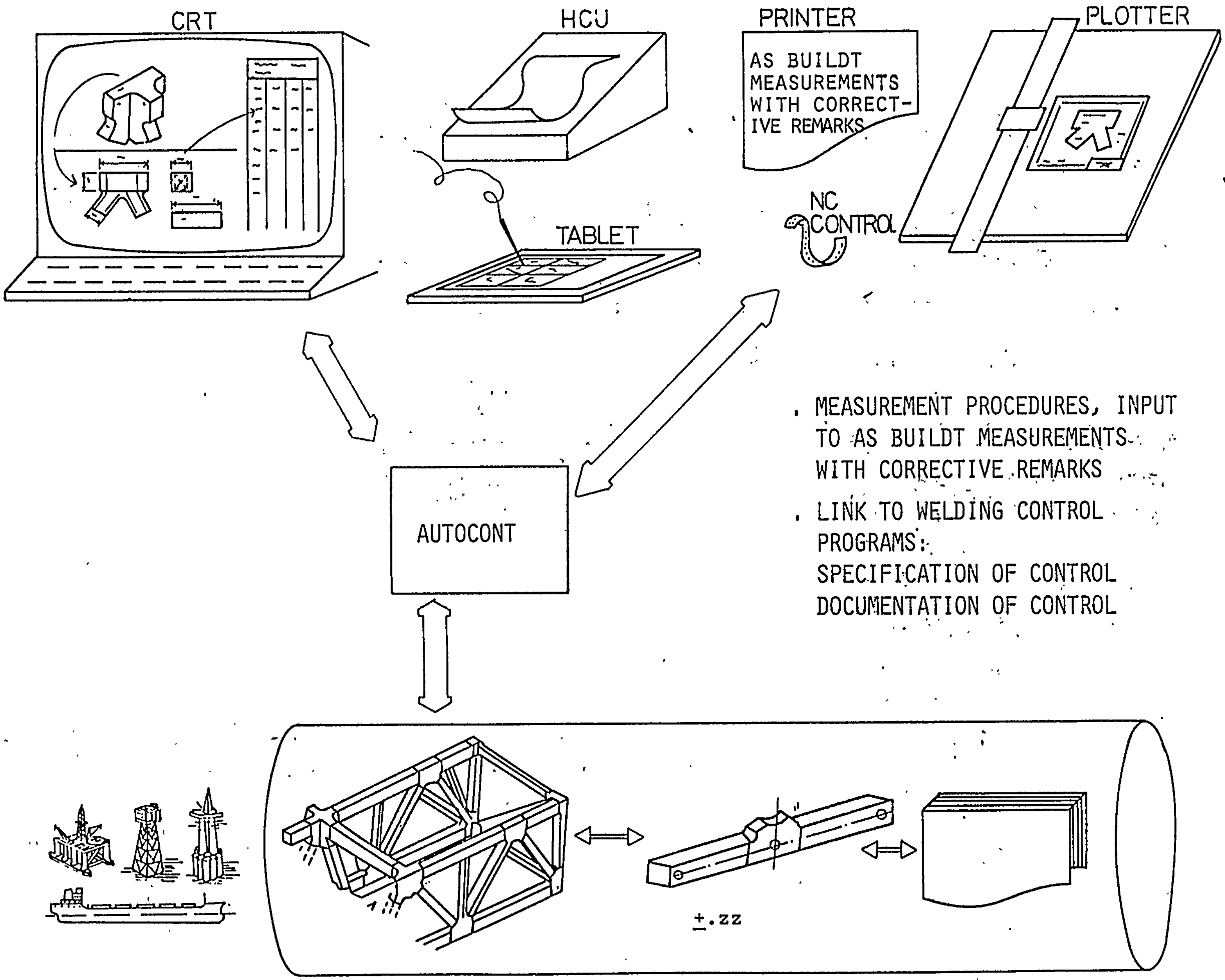

CRT
HCU
PRINTER
PLOTTER
TABLET
NC CONTROL
AUTODRAW
. GRAPHICAL PRESENTATION OF THE PRODUCT MODEL
. 2D OR 3D VIEWS
. COMPOSITION AND EDITING OF DRAWINGS
. FULL COORDINATION OF DRAWINGS AND THE PRODUCT MODEL
. STANDARDIZATION OF DRAFTING TECHNIQUES
. DOCUMENT ARCHIVE

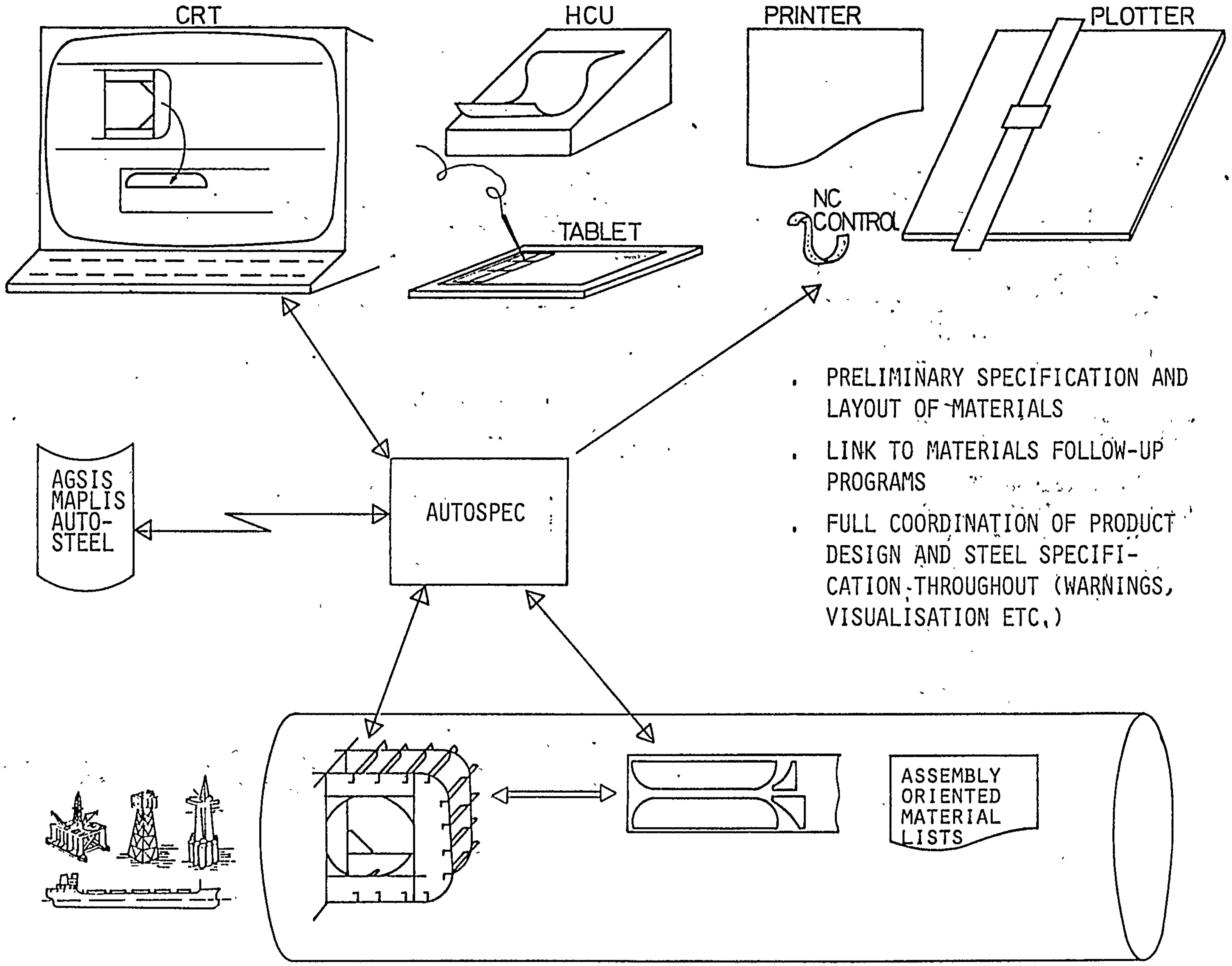
Fig. 9.

Fig. 10.



INTERACTIVE AUTOKON

Fig. 11.


CRT
HCU
PRINTER
PLOTTER
TABLET
NC CONTROL
AGSIS
MAPLIS
AUTO-
STEEL
AUTOSPEC
. PRELIMINARY SPECIFICATION AND LAYOUT OF MATERIALS
. LINK TO MATERIALS FOLLOW-UP PROGRAMS
. FULL COORDINATION OF PRODUCT DESIGN AND STEEL SPECIFICATION THROUGHOUT (WARNINGS, VISUALISATION ETC.)
ASSEMBLY
ORIENTED
MATERIAL
LISTS

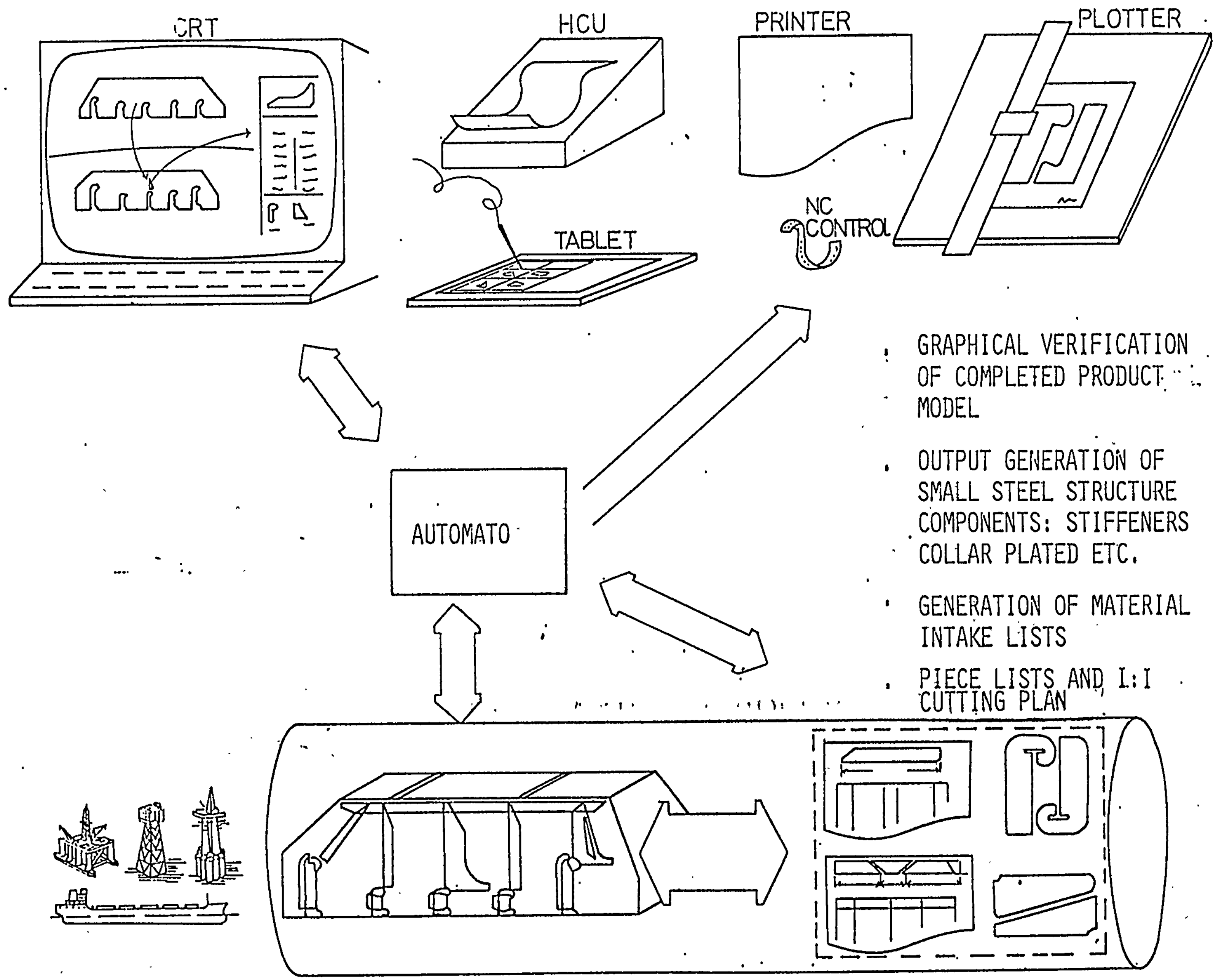

CRT
HCU
PRINTER
PLOTTER
TABLET
NC CONTROL
AUTOMATO
GRAPHICAL VERIFICATION OF COMPLETED PRODUCT MODEL
OUTPUT GENERATION OF SMALL STEEL STRUCTURE COMPONENTS: STIFFENERS COLLAR PLATED ETC.
GENERATION OF MATERIAL INTAKE LISTS
PIECE LISTS AND I:I CUTTING PLAN

Fig. 12.

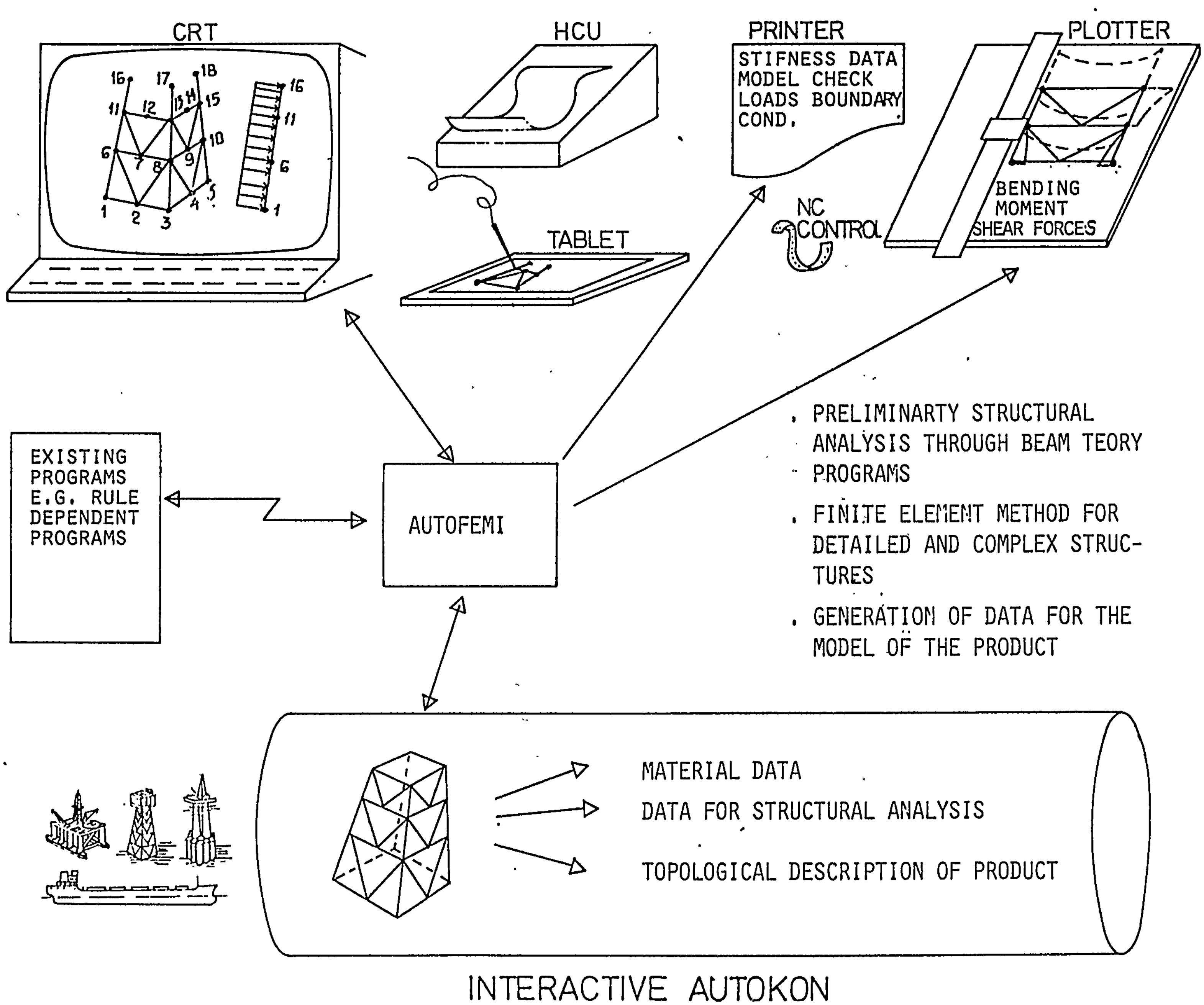

CRT
HCU
PRINTER
PLOTTER
STIFNESS DATA
MODEL CHECK
LOADS BOUNDARY
COND.
TABLET
NC
CONTROL
BENDING
MOMENT
SHEAR FORCES
EXISTING
PROGRAMS
E.G. RULE
DEPENDENT
PROGRAMS
AUTOFEMI
. PRELIMINARTY STRUCTURAL ANALYSIS THROUGH BEAM TEORY PROGRAMS
. FINITE ELEMENT METHOD FOR DETAILED AND COMPLEX STRUCTURES
. GENERATION OF DATA FOR THE MODEL OF THE PRODUCT
MATERIAL DATA
DATA FOR STRUCTURAL ANALYSIS
TOPOLOGICAL DESCRIPTION OF PRODUCT
INTERACTIVE AUTOKON

Fig. 13.

5. DEVELOPMENT SCHEDULE

AUTONEST is operational and available.

The other applications (subsets) shown in fig. 6.

AUTOPART
AUTODRAW(S)
AUTOMATO
AUTOCONT(S)

are scheduled for completion in a NORD-10/S version within medio 1979 and expected to be available for release utlimo 1979.

The remaining functions are partly developed in parallel to the extent needed for coordination, but are treated in the following order of priority:

AUTOMODL
AUTODRAW (enhanced version)
AUTOSPEC
AUTOCONT (enhanced version)
AUTOPREL
AUTOFEMI
AUTOPROD
AUTOPLAN

The entire development program is scheduled to be completed in 1982.

PRESENT SIAG-DEVELOPMENTS

PART 3

A U T O F I T

Presented by
P.F. Sørensen, SRS

1. INTRODUCTION

AUTOFIT is an abbreviation for automated outfitting.

AUTOFIT is a computer based technical information for piping design and production engineering. The system includes all main functions such as design, lay-out, work preparation and material take off. AUTOFIT provides a "product model" which is instrumental as a source of information to other tasks or functions: analyses, planning, shop automation and not to forget other engineering functions.

AUTOFIT as a system concept is common for all outfitting problems of similar nature, such as piping, wiring and ducting, even if implemented only for piping and instrumentation.

AUTOFIT is basically independent of product which makes it equally applicable to any piping system irrespective of purpose: ships, offshore vessels, petrochemical and chemical plants, whether off-shore or on-shore.

Communications between the user and the AUTOFIT information system is based on extensive use of interactive graphics techniques.

2. OUTLINE OF AUTOFIT

Fig. A1 shows the major tasks involved in the total process of piping design and production engineering, including material take-off.

Done in the conventional way, these tasks may be divided into three rather logical phases:

- functional design, resulting in a P & I diagram with all associated information in the form of drawings, lists etc.
- lay-out design, using either orthogonal arrangement drawings or building a small scale physical model, both visulizing the final arrangement.

  Both phases involves a variety of calculations and analyses.
- preparation of work shop documentation, such as isometrics, price drawings, material lists, etc.

In parallel with these tasks, the designer has to do material take-off.

The figure indicates which tasks of conventional process are included in the computerization. It appears that design of flow diagrams or systems schematics is assumed to be done manually.

Fig. A2 shows a general view of AUTOFIT, divided into main functions or sub systems, which correspond very closely to the sub-division of work just described.

DIAGRAM	:	covering functional design
LAYOUT	:	covering layout design
ISOMET	:	for workshop documentation
MTO	:	for material take-off
CALCUL	:	covering analyses and calculations

A brief description of each subsystem is given below together with the status.

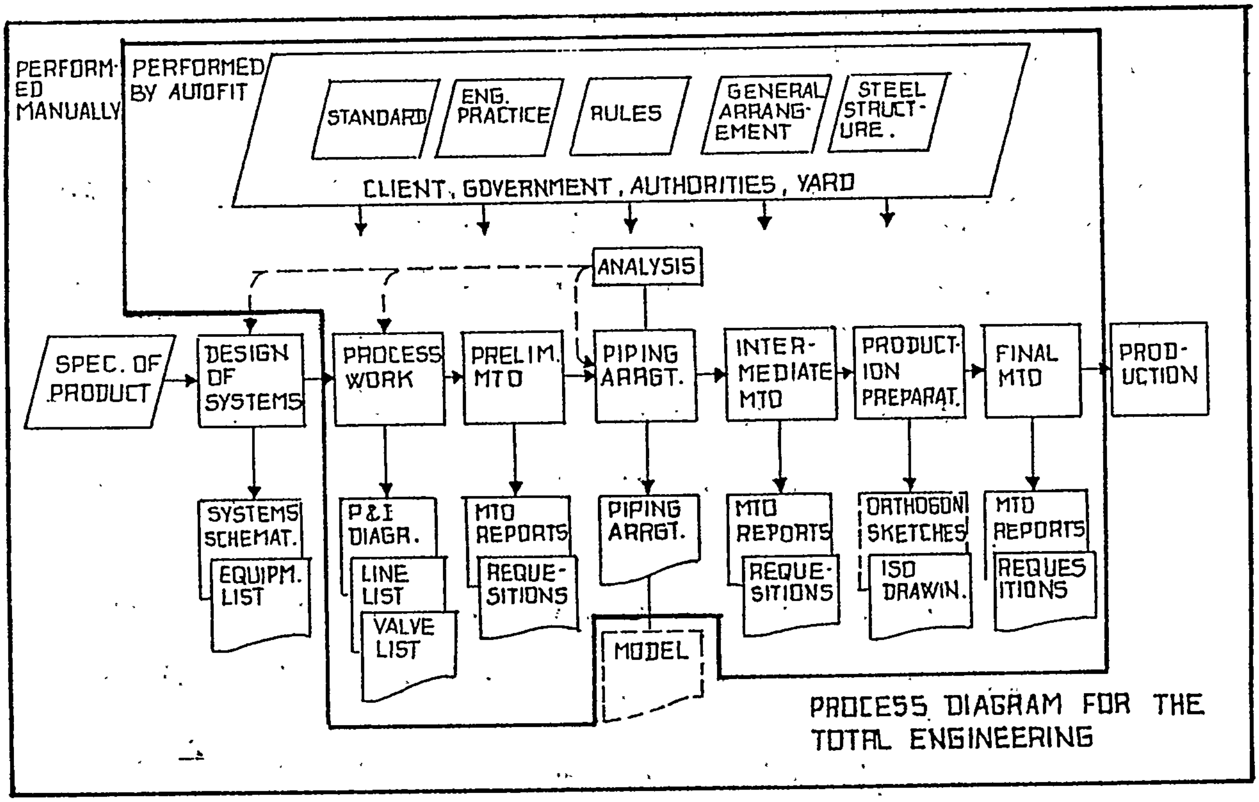

PERFORMED MANUALLY
PERFORMED BY AUTOFIT
STANDARD
ENG. PRACTICE
RULES
GENERAL ARRANGEMENT
STEEL STRUCTURE.
CLIENT, GOVERNMENT, AUTHORITIES, YARD
ANALYSIS
SPEC. OF PRODUCT
DESIGN OF SYSTEMS
PROCESS WORK
PRELIM. MTO
PIPING ARRGT.
INTERMEDIATE MTO
PRODUCTION PREPARAT.
FINAL MTO
PRODUCTION
SYSTEMS SCHEMAT.
EQUIPM. LIST
P&I DIAGR.
LINE LIST
VALVE LIST
MTO REPORTS
REQUESITIONS
PIPING ARRGT.
MODEL
MTO REPORTS
REQUESITIONS
ORTHOGON SKETCHES
ISO DRAWIN.
MTO REPORTS
REQUESITIONS
PROCESS DIAGRAM FOR THE TOTAL ENGINEERING

Fig. A1

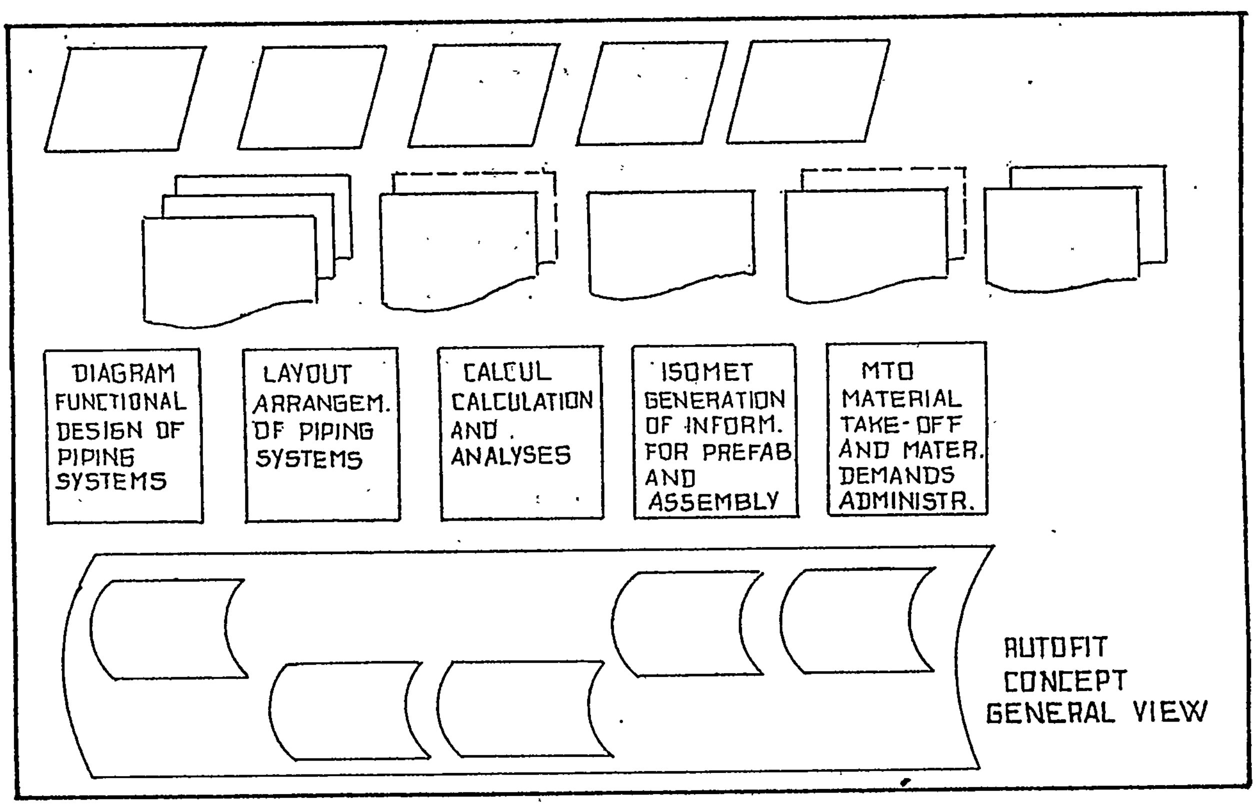


DIAGRAM FUNCTIONAL DESIGN OF PIPING SYSTEMS
LAYOUT ARRANGEM. OF PIPING SYSTEMS
CALCUL CALCULATION AND ANALYSES
ISOMET GENERATION OF INFORM. FOR PREFAB AND ASSEMBLY
MTO MATERIAL TAKE-OFF AND MATER. DEMANDS ADMINISTR.
AUTOFIT CONCEPT GENERAL VIEW

Fig. A2

2.1 DIAGRAM

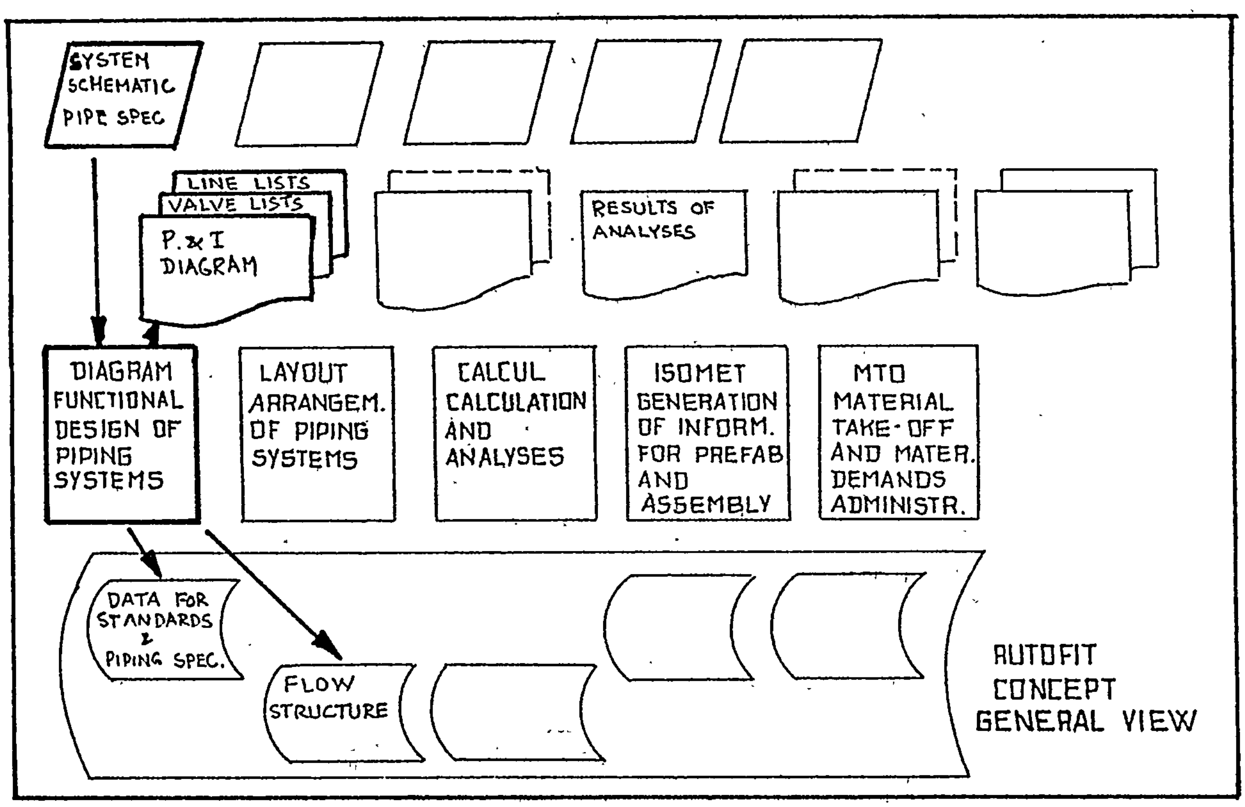
Covers the process up to and include complete P + I diagrams. Besides offering interactive drawing facilities, DIAGRAM is used to establish the flow-structure (topology) of the various piping systems and their instrumentation in the data base. Furthermore the database will contain pipe specification, standards and norms, component and instrument data. The DIAGRAM database provides input data to MTO for initial material summaries for purchasing and to LAYOUT for physical layout and routing and to CALCUL for various calculations.

The interactive schema drawing facilities are operational on NORD-10 x using Tektronix 4014/1. The screen menue is operated by the cross-hair. Drawings may be hard copied or directed to the plotter when final drawings are desired.

The remainder functions of DIAGRAM now under implementation are mostly interactive, but some intended for bulk input will use card reader as alterantive. However, totally, DIAGRAM will be operated on NORD-10. Since NORD-10 is used also as RJE terminal, card reader, line printer and paper tape punch are available.

DIAGRAM is scheduled for completion within 1979.

x Norwegian mini computer produced by Norsk Data, Oslo.



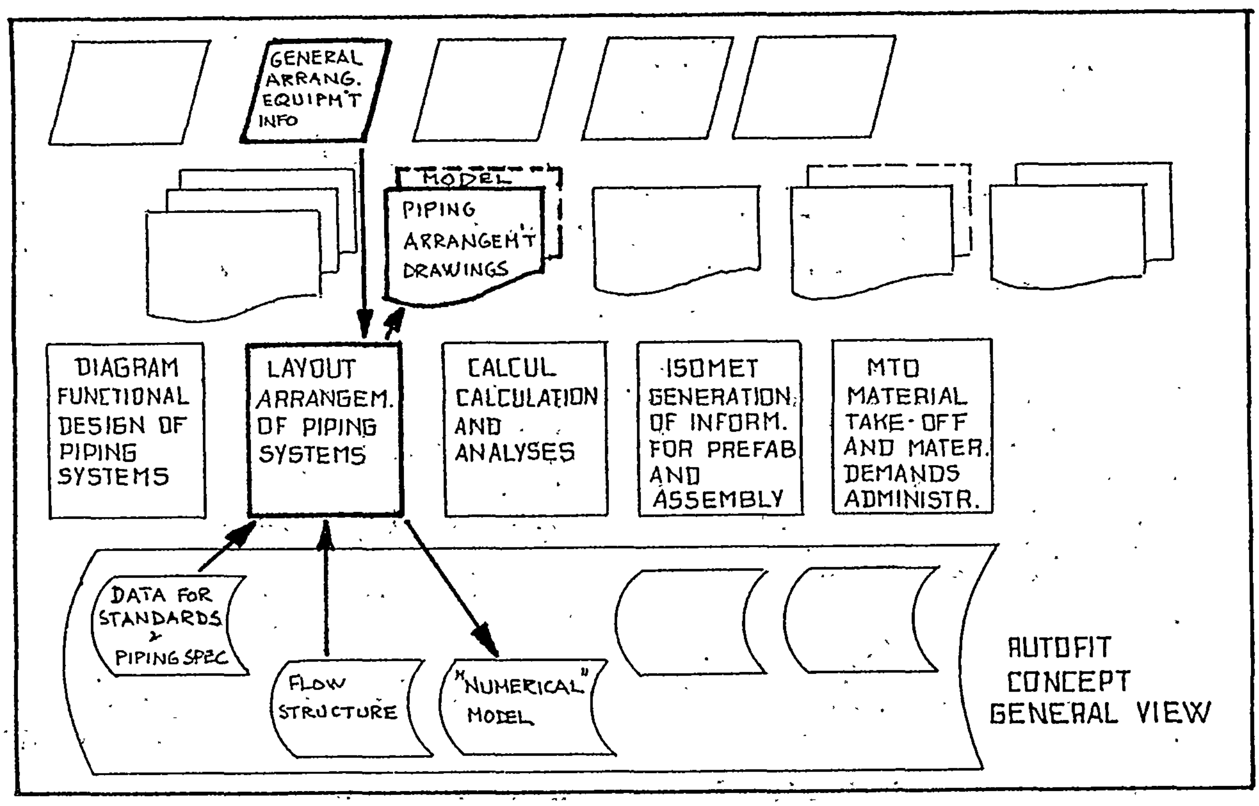
2.2 LAYOUT

Covers the continued process for providing complete piping systems arrangement with the corresponding numerical "model" in the data base. LAYOUT offers interactive facilities for definition of surroundings and constraints, volumes of components and restricted areas, for simple or automated routing and interference control and powerful facilities for vizualization and drawing. LAYOUT contains facilities for automatic selection of fittings according to standards and norms.

The LAYOUT database provides input to MTO for updated material summaries for purchasing, to ISOMET for generating work shop information and to CALCUL for various calculations.

This subsystem is specified and designed. An "experimental" version will be ready in August 1978, the purpose of which is to gain experience with interactive graphics in component and lay-out definition and simple routing.
A first version of LAYOUT is scheduled for completion first half of 1980, and an enhanced version with numerical interference control and automated routing primo 1981.

Since this subsystem is characterized by a very high degree of interactivity, it will be implemented on NORD-10. Tektronix 4014/1 will be used, but it is planned to use refresh screen as well.



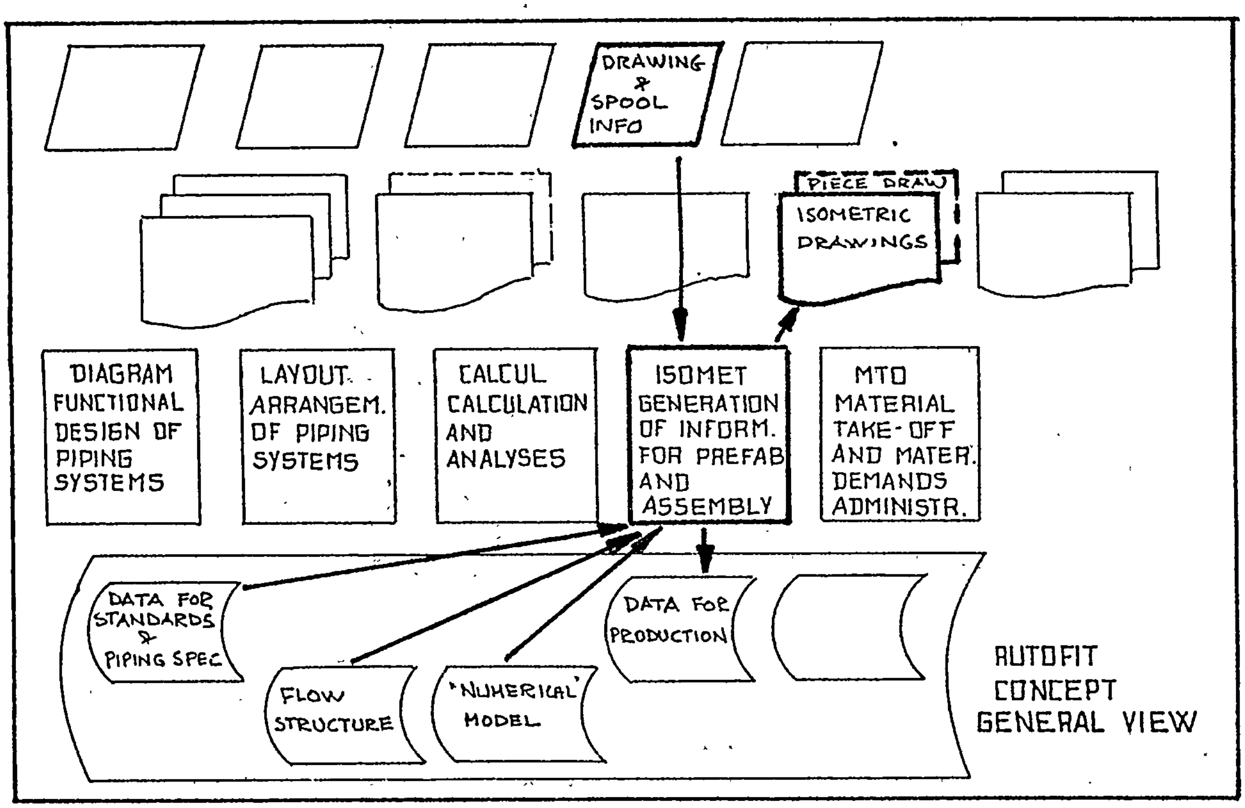
2.3 ISOMET

Covers the continued process of breaking down the arrangement in assemblies and pieces for prefabrication and automatic generation of the necessary drawings and other work shop informaton, including N/C bending tapes. If necessary, the drawings may be edited and manipulated interactively.

The ISOMET database provides input to MTO for final material summaries for purchasing. Since the ISOMET database contains full description of pipe elements, this information may be utilized also for various shop automation purposes.

The present version of this subsystem is a stand alone version operated partly on Univac, partly on NORD-10. By nature ISOMET is a typical "output" system with the purpose to convert, manipulate and present data base information in a rather repetitive and standarized way (isometrics, pipesketches, lists). The need for interactivity is less than in DIAGRAM and LAYOUT, and ISOMET is therefore characterized by a very high degree of automatic output. The ISOMET input programs are temporary and intended for bulk input lifted from a model or a conventional arrangment drawing. The input as well as the output programs providing automated output and therefore operated on Univac, while interactive editing of this output is performed locally on NORD-10.

When the databases from DIAGRAM and LAYOUT are available on NORD-10, the ISOMET subsystem will naturally be residing on the same computer.



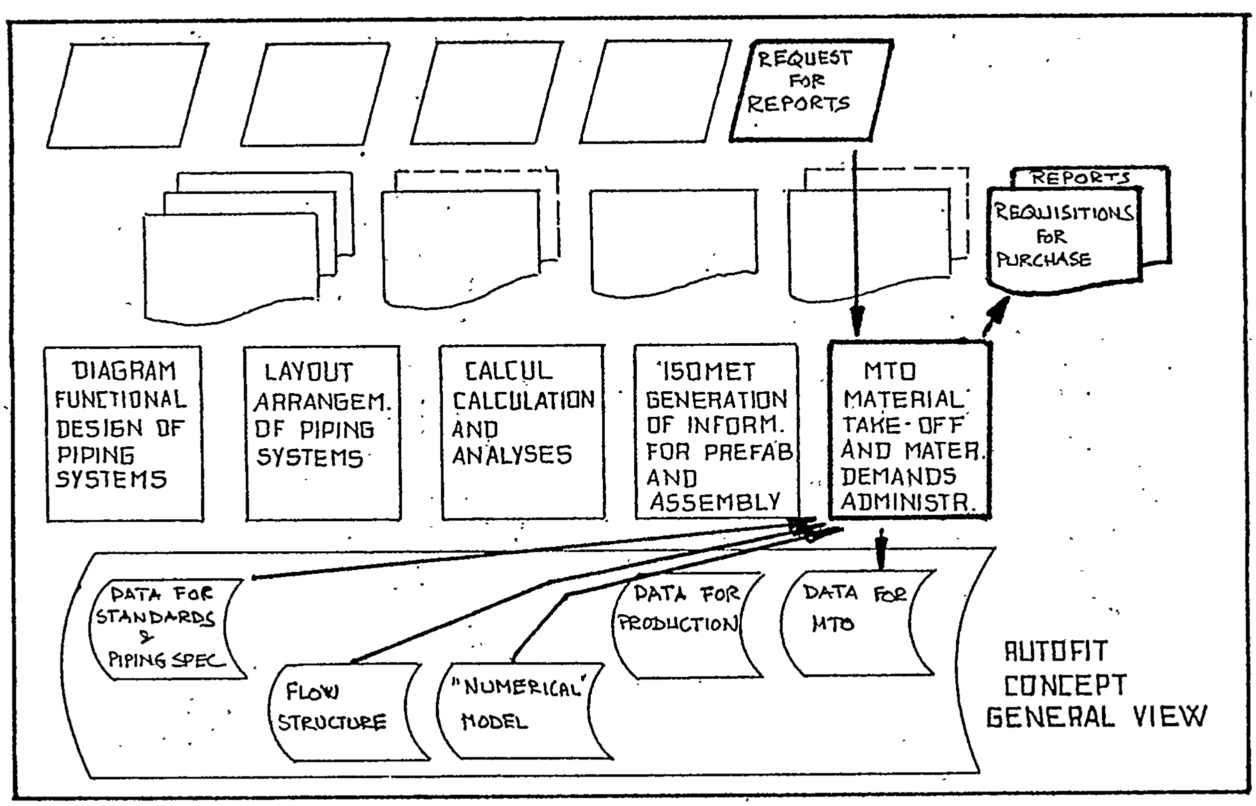
2.4 MTO

MTO extracts information from the "product" database and generate material demand summaries corresponding to the current engineering status. MTO provides material requisitions automatically and may also give material summaries sorted on different criterias such as: line no., area (block) no., group no., (for cost summary), activity no. (for planning), on materials code (for bulk ordering), contract type (for billing of extras), type of work (prefabrication or assembly), etc. MTO is command oriented and is presently operated in batch.

MTO provides information to the material administration system for order follow-up and warehousing. The purchase order no. is fed into MTO, which is capable of giving a complete status or requisitions and orders versus demands.

MTO is operational on Univac 1100 as a stand alone system with output as described, however, partly with provisional input programs, awaiting the availability fo the final product data base from DIAGRAM, LAYOUT and ISOMET. By then, MTO will become a typical output system.

The necessary links are designed and are scheduled for implementation concurrently with the completion of the previous subsystems. The intention is also to implement it on NORD-10 for operation in conversational mode.



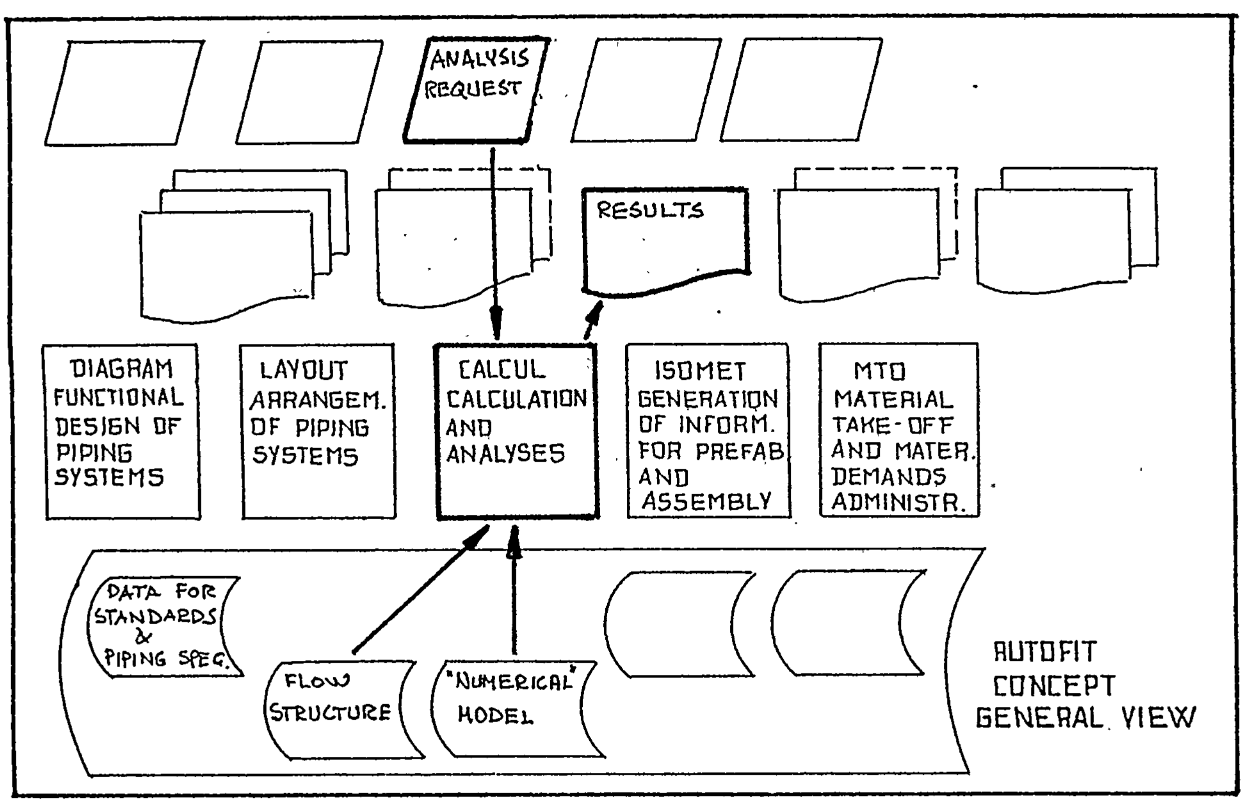
2.5 CALCUL

The flow-structure (topology) description and function data from the DIAGRAM data base and the 3-dimensional numerical model from the LAYOUT database serve as reference for various calculations which are performed in the respective phases. Such calculations may comprise mass balance, pressure drop, structural strength, analyses, etc. The extent and type of calculations will depend on type of piping system, industry, rules and regulations and other user dependent demands.

Therefore, CALCUL is more an opening to each user of AUTOFIT to rewrite present programs or develop his own new programs in interface with the AUTOFIT data base, rather than an off-the-shelf library provided as standard AUTOFIT routines.

Calculation and analysis programs are usually batch or in some cases operated in dialogue mode. Possibly except for structural calculations by advanced FEM systems available on large main frame, it is assumed that most calculation programs may be accommodated on the same computer as AUTOFIT.

There are no specific plans to develop calculation programs as off the shelf packages as part of AUTOFIT.



3. HARDWARE

Great efforts are made to develop AUTOFIT as a portable and self-contained software with the highest possible degree of hardware independence.

Nevertheless, certain hardware have been selected during development, mostly because of availability and partly because of choice for several concurrent developments.

The hardware being used comprise general purpose equipment such as:

- o Univac 1110 as central main frame.
- o Nord-10 as local machine for interactive graphics, for RJE terminal connection to Univac and for plotter control.
- o Tektronix 4014/1 with EGM option, tablet and hard copy unit.

The operational mode of the various subsystems are already described. However, it does not necessarily represent the final solution when AUTOFIT is completed.

Since AUTOFIT is basically portable, the user is given a certain amount of freedom to pick hardware such as computer, screen and plotter.

As appearant today, a minimum computer requirement for accommodation of AUTOFIT will be 192 K words, 2 discs drives, 1 tape station, card reader, line printer, paper tape punch. The final configuration in terms of capacity cannot be specified in detail now, simply because the system is not yet completed.

Other capacity demands such as number of work stations (screens) are set by the user environment: volume of work to be performed, the geographical distribution of work and whether the same hardware and work stations are intended also for other applications. The core requirements on Nord-10 will increase with the number of work stations in a multi user mode operation.

It is technically feasible to operate AUTOFIT on Univac 1100. The efficiency is, however, entirely dependant on the computer center operation policy and work load.

PRESENT SIAG-DEVELOPMENTS

PART 4

<u>Hardware Considerations in the</u>

<u>AUTOKON/AUTOFIT projects</u>

Introduction

This part of the AUTOKON/AUTOFIT will deal with the following aspects

- o Trends in Hardware development
- o AUTOKON/AUTOFIT hardware considerations
- o Graphics hardware development
- o How does the "turnkey" systems fit into the total AUTOKON/ AUTOFIT system
- o SRS - SIAG development policies

1. What types of systems are AUTOKON and AUTOFIT ?

Let us review two important points

a Information Systems

This means: They are to be considered a central information source from which the different application programs (which belongs to AUTOKON/AUTOFIT) fetches and stores data.

b Topological product model

The key to this information is a product model which is a logical description of how the different parts and prices of the product are tied together.

To administer this information consisting of topology and geometry requires a powerful and resource demanding Database system. The storage requirements are also great.

In addition several applications, with several users each, may wish to access this informations simultaneously.

Finally most of the applications wish to utilize interactive Computer graphics as a means of communication between the user and the information system.

In order to evaluate the possible hardware configurations for these resource demanding systems it is necessary to take a look at hardware development trends in general.

2. Hardware trends

The hardware development trends for todays MINI/MIDI computer can be explained by the following points

- o The introduction of LSI (Large Scale Integration) technology is bringing the price and size down on basic components. (CPU's, memory etc.)
- o Due to this fact there is a tendency to move in the direction of 32 bit hardware (instead of 16 bit).
- o MICRO computers will be used as logical components for functions such as
  - driwing plotters and digitizers
  - interfaces towards equipment
  - etc., etc.
- o MULTI - CPU architectures where a particular CPU may be assigned one particular function or task

  ex.
  - Database function
  - display handling
- o Distributed processing utilizing several computers connected together. This has a positive influence on the following factors
  - Expandability
  - Total system downtime
  - Graphics devices may be connected through short high speed lines
  - etc.

Example of the last two points are shown on fig. 1 and 2.

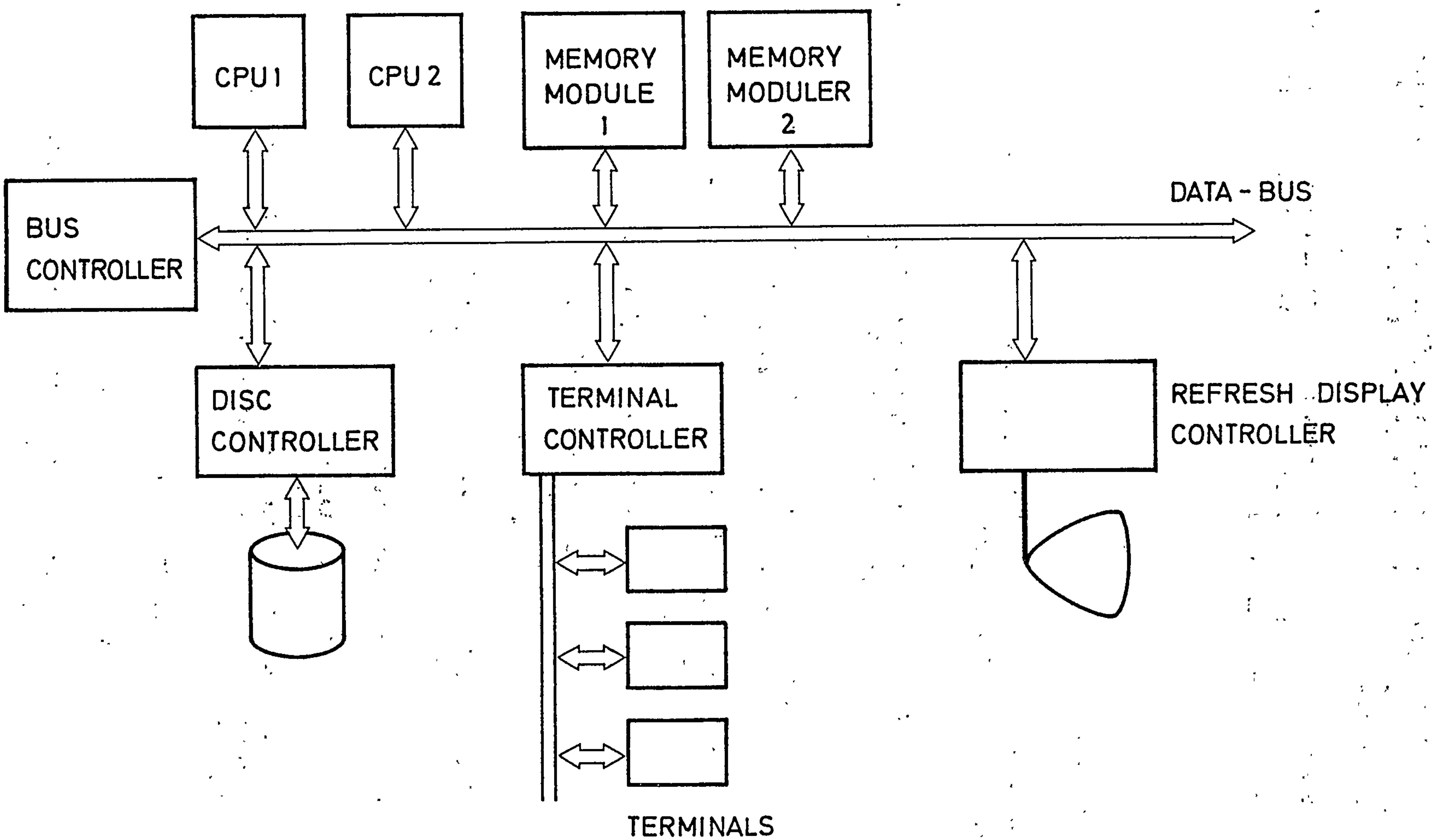


Fig.1 MINI COMPUTER HARDWARE ARCHITECTURE

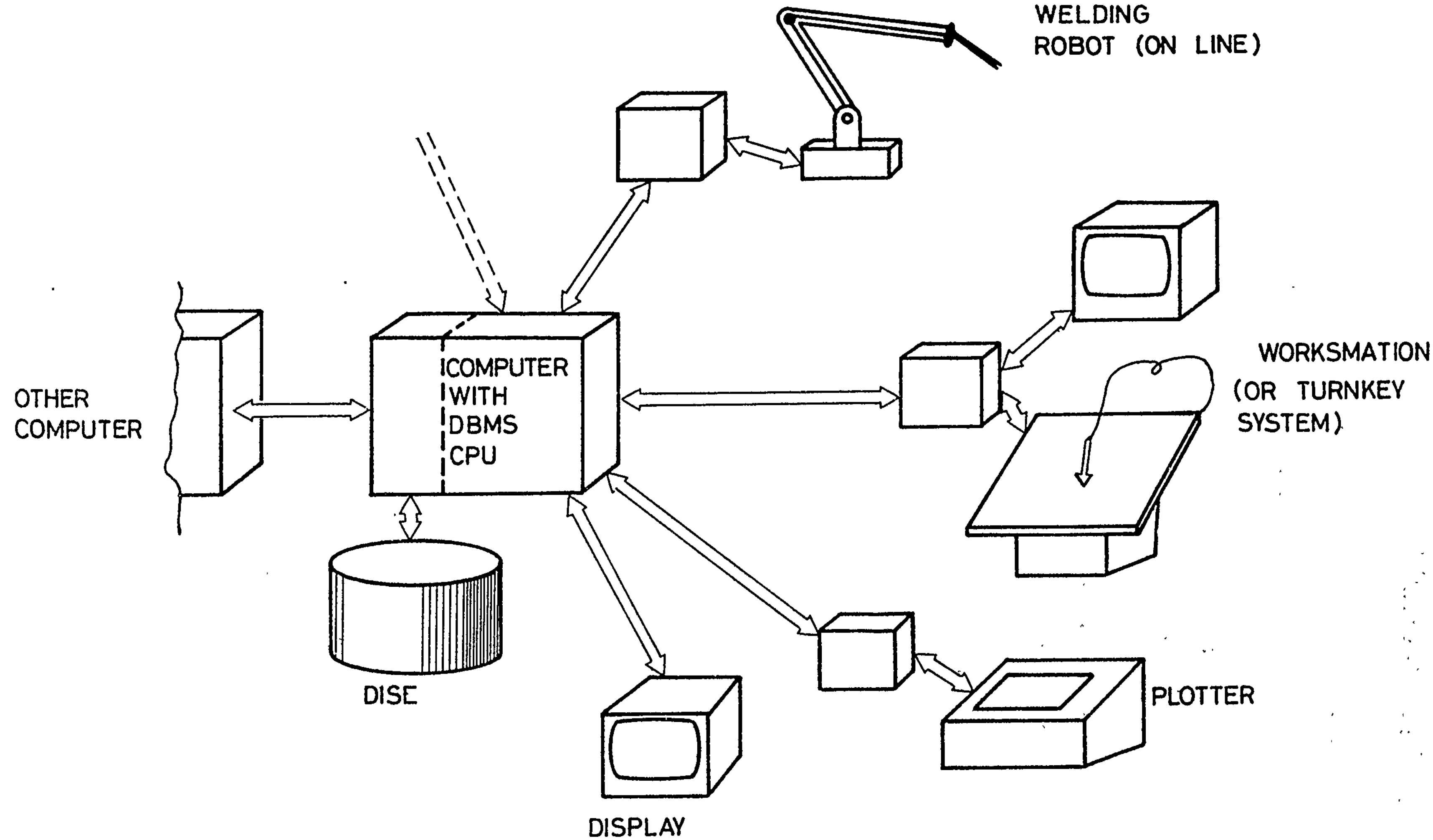
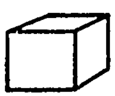


Fig.2 FUTURE "MINI" CONFIGURATION

 microcomputers or intellegent controllers

3. AUTOKON/AUTOFIT estimated performance

We have tried to estimate resource demands based on equipment we already know.
The machine configuration for the estimate is a NORD 10/S 16 bit mini computer with

- o 192 - 256 K 16 bit word memory
- o 5 - 6 terminals (of these 3 tektronix 4014)
- o Mass storage 66 - 100 Megabytes
- o Magnetic tape station
- o On line plotter

The following performance was "estimated".

LOAD:

3 - 5 users simultaneously

- on same or different sub-systems
- on same or different database
- sporadic communication with systems on other machines

RESPONSE TIMES:

- Graphical interaction 2 - 5 sec.
- Updating database 1 ÷ 30 sec.
- switching application 1 - 5 min
- changing (redefining) product model 1 - 6 hours

It should be noted that data given for storing on the database covers aspects from storing of simple geometry to complex topological structures.

4. Graphics Hardware development

Just like for the MINI computer the LSI technology will make a huge impact on the Graphics hardware

A typical Graphics System will contain one or more microcomputer: performing different functions such as

- Picture processor for Refresh System. This indicates that refresh systems will be more attractive(maybe in connection with storage capabilities)
- Communication processor to host computer
- Basic Graphics functions such as
  - 2D/3D transformations
  - Window/viewporting
  - "Hidden line" removed

On the whole this indicates cheap workstations capable of acting as stand alone systems for certain input/output function, f. inst. digitizing, drawing editing etc. in much the same way as the Turnkey systems of today only at a much lower price.

However, we see these work stations only as graphic input/output devices for the total information system capable of doing some stand alone functions,not as a medium for implementing the total system.

This would only serve to concentrate the processing problems as the work station instead of distributing the processing between the workstation and the total information system.

5. How do we prepare for known and unknown turnkey systems ?

The introduction of graphical turnkey systems or work stations allows us to reduce the processing load on the host computer(s).

However, they do introduce the problem of defining "software intersection" between the host computer(s) and the workstation since no two turnkey systems look alike

- o they supply different functions
- o they represent data differently (f.inst. geometry)

In order to reduce the amount of work involved in integrating a turnkey system the following aspects have been given attention

- o To separate the Topology and Geometry description of the product. While many turnkey systems handle geometry adequately they do now handle your particular products topology

- o To separate functions that

  - manipulate topology
  - manipulate geometry

- o To separate functions that manipulates graphics data

  - Display code generation
  - Display code manipulation
  - 2D & 3D transformation
  - etc.

- o To base the development on identical software packages or building blocks to reduce overal maintenance and adjustment to new turnkey systems

  - Database/file systems
  - Command processor
  - Graphics software
  - Geometry routines
  - Text manipulations
  - Documentations
  - etc.

6. Development policy

We would like to finish by summing up our development policies

- PORTABILITY

  We do want to make portable systems. This means independance of hardware, both computer and turnkey/workstation, although this does not allow us to optimize on a given configuration initially. It allows us to adjust to new hardware that comes along (or hardware already in a yard).

- SOFTWARE STANDARDIZATION

  We are attempting to base our development on common software packages.

- We develop for 16 bit minis with an address space of 64 words although we believe that the 32 bit machines will dominate in the future.

- We believe in MINIS (or MIDIS) for interactive work either connected to other MINIS (MIDIS) or to main frames.

- We do develop using Tektronix 4014 but try to accomodate the cheap, intelligent work stations that we believe are comming.

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