PRODUCT STRUCTURING AND CIM

INTRODUCTION

Integrated Manufacturing requires a deep knowledge and understanding of development as a process including products and the corresponding production, service and recycling. This is "a must" to recognize the ways and means to attune better the respective functions to fulfill and to decide on simultaneous design and engineering. At the same time, integration depends on the effective transfer of information upwards and downwards the development sections and in between the parallel activities. Direct relations between product design and specific manufacturing activities require per situation an accumulation of technological knowledge and technical skills. After matching design and production the related procedures have to be recorded with the correct accuracy; see the top-line in figure 1.

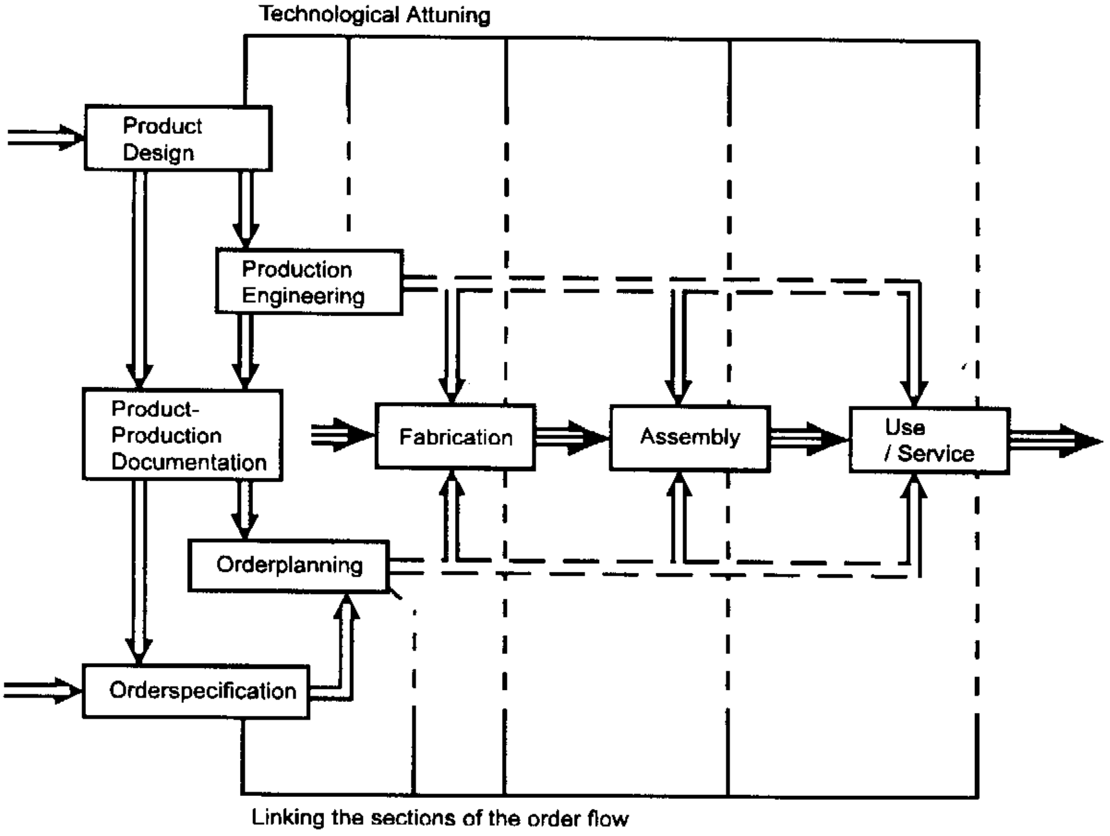
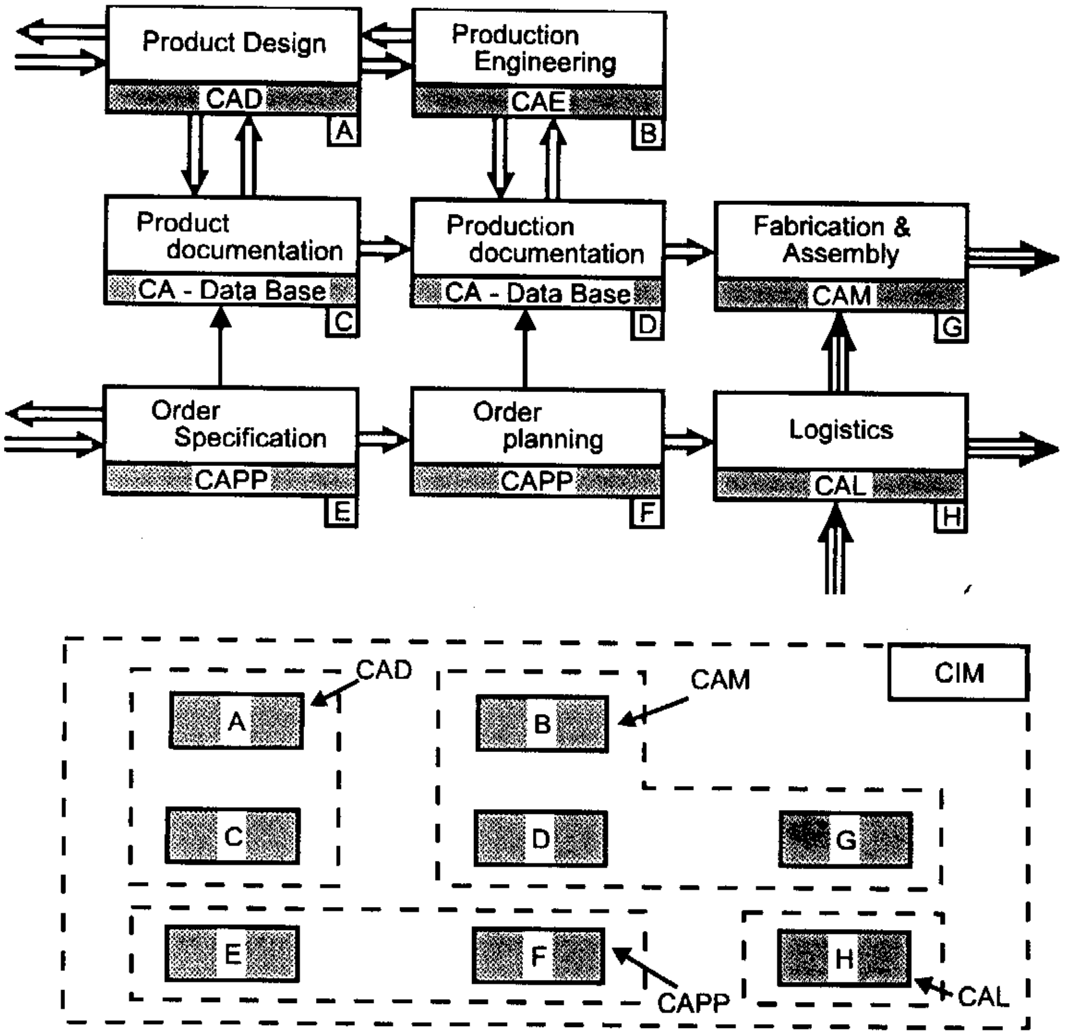


Figure 1. 'Tuning' the sections of the primary process

Prof.ir. H. Bikker - Section Industrial Organization and Management - Faculty of Mechanical Engineering and Maritime Technology - Delft University of Technology
- Phone (31-15)782711, Fax. (31-15)783057 - Mekelweg 2, 2628 CD Delft, The Netherlands

Each time the investments have to be confronted with the gains of quality improvement and/or the reduction of leadtime and cost. In many cases the production is not directed immediately from the drawing-board. As usual a build up of product- and production-documentation is inevitable when manufacturing product families and in case of anticipated modularized design.
In the orderflow the specifications are applied as necessary see the bottom-line in figure 1. Besides the technological attuning well-designed links are required between the successive sections of the orderflow. The figure 2 presents the vital relations of computer aided processes in the integral CIM-development.



CAD = Computer Aided Design
CAM = Computer Aided Manufacturing (Engineering included)
CAPP = Computer Aided Production Planning
CAL =

Relations CAD - CAM (CIM - route 1) } CIM
$\frac{\text{CAPP}}{\text{CAD}}$ - $\frac{\text{CAM}}{\text{CAL}}$ (CIM - route 2)

Figuur 2 **Vital relations between computer aided processes**

The productstructuring is playing its role on different levels:
- It reflects the requirements of the assembly activities, the service and fabrication.
- It reflects the build-up of a product assortment.
- It is a strong means in stimulating parallel design and engineering.

THE BASIC DILEMMA

The dilemma facing the companies contains contradictions. The dilemma reads: how to meet customer requests for product flexibility while improving productivity and lead-time.

Especially in the case that clients require specials they have a few options for the product information flow and the hardware flow. For the product information flow, companies might reduce further on lead-time through:

- introducing new technologies;
- concurrent and simultaneous engineering;
- re-use of constructions.

The introduction of new technologies, concurrent and simultaneous engineering will not always have the desired effect. These options will reduce delivery time but they approach the specific client requirements from a project-oriented point of view. The re-use of constructions makes it possible to apply already developed constructions and assemblies.

For the hardware flow companies have as an option:

- manufacture on stock in an appropriate point.

This extra stock point is called the Custom Order Entry Point. Although risks of investing in stock might increase, the introduction of such a point will enable a company to reduce on delivery time.

Re-use of constructions

The dilemma for the engineering process remains to be: how to reduce costs by re-use of constructions and at the same time reduce on total lead-time while clients do request specials.

Custom Order Entry Point

The point where an order penetrates into the hardware flow, the Custom Order Entry Point (COEP), determines which specific activities have to be undertaken after the start of a custom order as seen from figure 3.

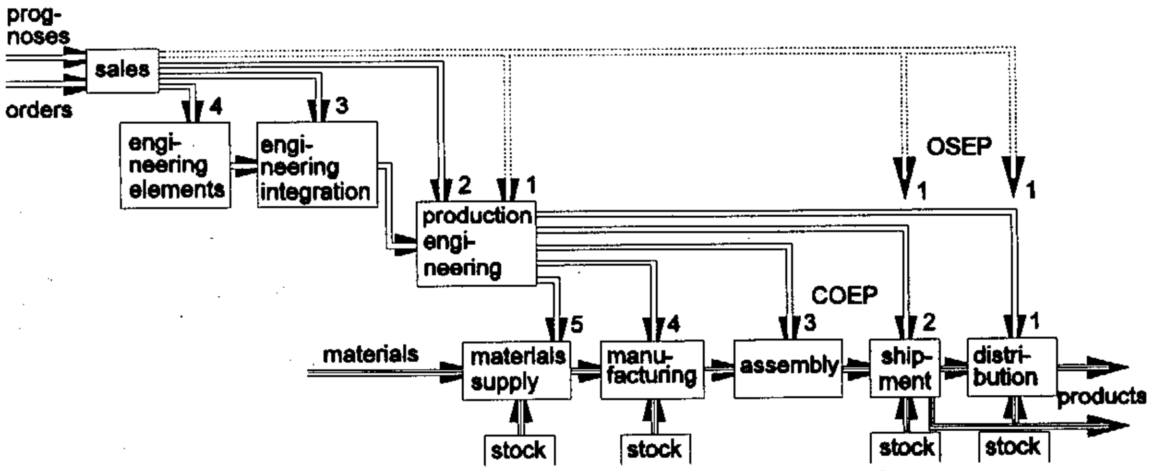


Figure 3: Detailed model of the sales, engineering and manufacturing process

On the extreme side where end-products are kept at stock, the effect of an order restricts itself to the distribution of the finished product (COEP-1). The second COEP indicates that shipment processes have to be included into the specific activities. When assembly activities belong to the execution of an order the COEP positions itself at point 3 and in the case of manufacturing of parts at point 4. Engineering on order will mostly result in purchasing specific parts and materials for that order and enters the manufacturing process at point 5.

Downstream of the COEP no stocks should be available for sale and the decisions mostly effect the risks and opportunities for accepting orders. Upstream decisions direct themselves at the risks coming along with investing in stocks The COEP represents in most cases the latest stock point in the logistic chain; from this point on client's orders have to be delivered.
The design of the product structure has a strong influence where an order might enter the manufacturing process.
The choice of the COEP determines mostly the perfomance of manufacturing. The decision for the COEP one derives from:

- the availability of the product specification for production;
- the permitted lead-time;
- the fequency of expected sales of individual modules;
- the capital investment in stocks.

Before this entry point, the prognosis of the orders guides the planning of manufacturing activities; for example, the production planning can be based on MRP. After this entry point, the emphasis on control of manufacturing shifts to lead-time and flexibility since specific customer requirements have to be met.

Order Specification Entry Point

As the hardware flow, the product information flow has as well a point where a custom order penetrates into the process. The product information flow generates the related specifications and instructions for the manufacturing process. The position of the Order Specification Entry Point (OSEP) indicates the amount of engineering work before any order is specified for 'production engineering'. The more the design and configuration has been developed on advance, the less the amount of engineering work that remains to be done for processing a specific order.
When the client accepts an order for an already defined product, the product information is then ready for manufacturing. In such a case, the order information is directly transferred to production engineering or shipment and distribution (OSEP-1 in figure 3). Position 2 of the OSEP indicates that production engineering has to transform the standard information from engineering into information for manufacturing; the order does not require any specific engineering. Engineering on order leads either to adaptations of existing constructions (OSEP-3) or a total dedicated design (OSEP-4).
The product structure has a strong influence on the position of this point. Any change in requirements from clients that leads to a new design or similar effects, moves the position of the OSEP to point 4 with its lead-times. Points 1 and 2 indicate how successful a company is in re-using constructions. The break-down of a product will mostly result in different positions for different constructions.

The position of the OSEP may vary from doing all design and engineering work on order to having completed all engineering work on beforehand. This crucial decision depends on the "calculated risk" of defining constructions before receiving actual orders, the prospects of applying these constructions during the product life cycle and the benefits in acquiring and processing orders.

The choice for a specific OSEP point does not necessarily indicate the use of a specific COEP point or vice versa. The choice of each point depends on rather independent factors. Since we distinguish two order entry points, these points might be put together in a matrix (see Diagram 1). Different products and constructions may require different positions of these order entry points in the Order Entry Matrix. When an OSEP for a certain construction allows acceleration of the order processing in the specification process, management has still freedom in positioning the COEP.

COEP

OSEP	1	2	3	4	5
1					
2			■		
3			■	■	
4					■

Diagram 1: Order Entry Matrix

The order Entry Matrix

When a company has different OSEP/COEP combinations, that might be attributed to three reasons. First of all, some constructions and components require only assembly for a specific order while at the same time specific materials have to be purchased. Secondly, special requirements influence only part of the total design; this implies that some parts are not effected while other constructions need a re-design to meet customer demands. Finally, the whole range of products of a company can have different combinations.

When looking at the original problem related to the engineering companies, the Order Entry Matrix reveals which measures to take for reducing the lead-time and increasing the productivity and flexibility. The way-out should be obtained by moving the entry points downstream. That way, lead-times will be reduced and the re-use of constructions improved

The implementation in the industry of this matrix shows considerable reductions in lead-time and costs in the design and manufacturing processes. Companies implementing the matrix and the modules reduce the impact of client specifications by offering a complete range of basic, standard and standard optional modules. By configuring the product structure in such a way that the impact of specials is as low as possible, it also improves the OSEP/COEP position; that way a proper product structure reduces the lead-times and improves as well the productivity of the total design and manufacturing process.

Pilot can I: the continuous sterilizator
A manufacturer of continuous sterilizators launched a project to optimize OSEP; this company produces these sterilizators for all types of food in pots and cans since 1960. The high complexity of the product and the low volume (5-10 orders per year) had resulted in a broad variety of components and the corresponding drawings. Any new order asked for engineering work on most of the components and of the component integration. The average lead-time of design, engineering and production totaled up to 9 months. Production started with purchasing materials, so the COEP was in position 5. At every new order, the OSEP was positioned just at the beginning of the design and engineering process (point 4). When the sales department had specified the requirements of a new order, the designers retrieved the associated component's design and drawings 'by mind'. The engineering data base was then fully order-oriented. The re-use rate of existing drawings had been calculated on 1.7 times.

Analysis
The first analysis led to the conclusion that the position of the COEP should not move since the risk of investing in unsalable stock would remain high. For the OSEP the following sub-problems were formulated:

- is it possible to select quicker the number of components?
- can component-integration start directly after receiving the order, thus introducing OSEP at position 3?
- will a push and pull relation between OSEP 4 and 3 improve the control of both the design and engineering of components and the integration?

The step taken consisted of classifying the most 'promising' components from the point of re-use and clustering the components belonging to the different product functions. This step defined 17 functions as basic required by any type of sterilizator and 6 functions as standard. Besides these 23 pre-defined functions, a customer might ask for 'specials'. A new retrieval system based on a modular design responded much more to the needs of the sales department, the designers and the engineers. This resulted in a better and quicker selection of useful components and the corresponding product documentation during the quotation stage. This allowed the engineering department to start the component-integration weeks earlier.
Now, the methodology of component-integration drew attention. Can a push and pull relation between OSEP 4 and 3 matches better to the needs for shortening the assembly time? For that purpose, the process model of figure 4 was used. At the left side of it, the assembly activities for a sterilizator make out the input; it creates a generic assembly parts list. The first step of the process determines a rough step-by-step assembly plan. After filtering superfluous data, a concept flowchart is drawn. This step reckons with assemble activities and hours in more detail. The third step concerns parallelization on one hand and balancing man capacity on the other hand.
This process as depicted in figure 4 results in the flow-chart of the assembly path. Such a chart provides the actual delivery dates of components to the assembly path; and these delivery dates provide the deadlines for the manufacturing of the components itself. The flow-chart serves also as the basis for component-integration using a generic assembly parts list. The evaluation function 'E' supplies information if the process standards need adjustment by the initiating

function 'I'. It derives this information from the evaluation of flow-charts produced by this process.

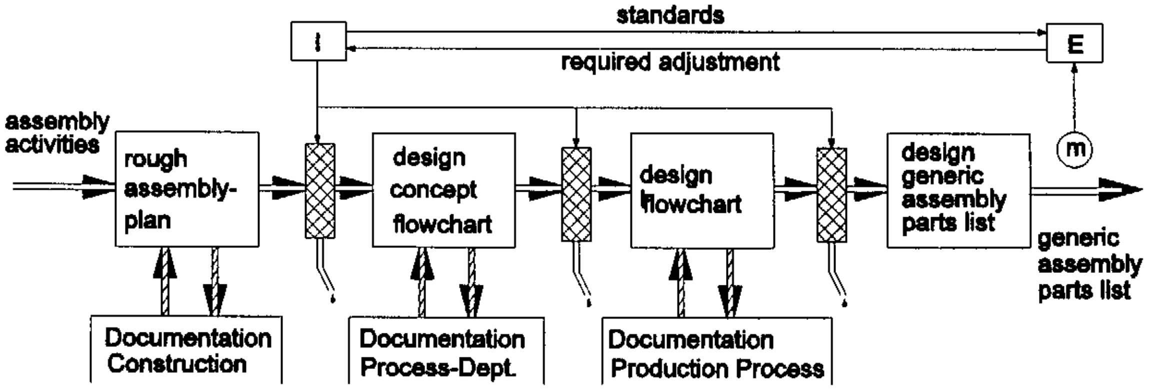


Figure 4: Steps for structuring the assembly

Results

The systematic development of the flowcharts and the generic assembly parts lists as a tool for component-integration led to a 3 month reduction of the delivery time in average. Management of 'production' and of 'design and engineering' were fully involved.

After an investigation period of 6 months, the manufacturer decided to implement the new documentation structure and work methods. The new documentation structures and work methods have been based on the new matrix positions of OSEP 4 and 3 while maintaining COEP 5. The basic and standard modules had the combination of OSEP 3 and COEP 5 while the specials were still located at OSEP 4 and COEP 5. Through the re-defined product structure the effect of client's requirements on the total lead-time had been minimized.

Pilot case II; The display counter

During 1992 Fri-jado, manufacturer of display counters, introduced the following problem: lead-time of the average order reached nearly 8 weeks and the market demanded shorter lead-times. Also, the effort for specifying the orders did not balance with the product price. In the existing situation 80% of the orders used OSEP 4 for the needed product information; only 20% of the customer requirements could be transferred directly to the integrating phase at OSEP 3. figure 5 shows their entry points into the specification process. In the hardware flow, orders used three different COEP's: positions 5, 4 and 3. Because a great part of the components had to be specified and manufactured on order, the position of COEP varied mostly between point 5 and 4. As shown in figure 6 at COEP 3, partially the vendors supplied the standard parts and components and partially the factory manufactured these parts necessary for the display counters. The sub-assembly respectively the final assembly could only start when all the new specified components became available. The lead-time of the 'hardware flow' totaled then 4.5 weeks; the specification phase took at least 2 weeks.

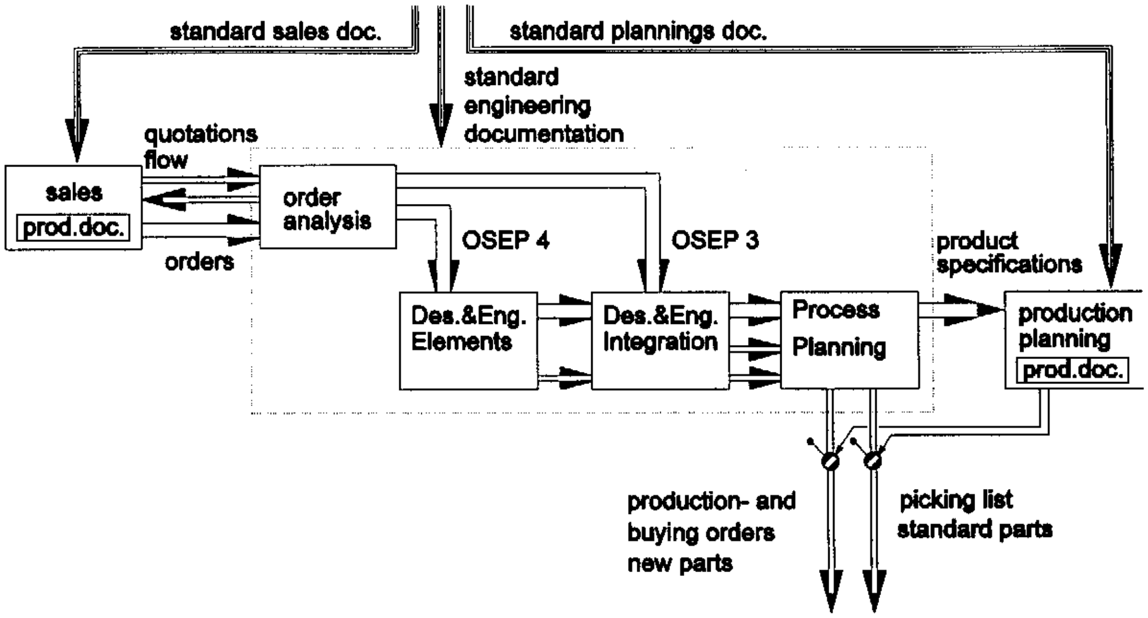


Figure 5: Order Entry Points of the specification process

Analysis

The starting point for improvement was to investigate if a greater part of the order information might enter the production information flow directly at OSEP 3 and 2. This might result in a more attractive distribution of components at COEP 3 and 4 from the logistic point of view. When 70% or more of the components could become available on prognosis at COEP 3, the assembly would start sooner after the confirmation of the order. The first step consisted of examining the possibilities to supply the sales department, the design and engineering department and the production planning department with product documentation oriented on product functions.

This resulted in the next step: Which product functions had to be defined? Figure 7 shows the primary functions of the display counters. If necessary, typical variants of product functions were defined like heating or cooling food. Defining a variant of a function means that absolutely different 'hardware' had to be installed. Sometimes a product function was split up in sub-functions. Then it had to be clear that sub-functions were related to their own specific sub-hardware components.

Results

After re-structuring the product family and the corresponding product documentation, 80% of the customer requirements directly flows on average to the product-integration at OSEP 3. The re-structuring of the product reduced the specification time to 1.5 weeks. As a result of this, the lead-time of the hardware flow could be reduced from 4.5 to less than 3.0 weeks. A product configurator was developed to translate the demands from the market-side to the needed components and materials at the production-side. Calculation of a quotation is highly reduced to adding relevant component prices. During 1993, further investments concerned the computer aids necessary to speed up the flow of order information between the sales department, design and engineering department, production planning and the material department. In this case, the structure of the order entry matrix was not really changed but it was much better tuned to the strategic requirements of the business.

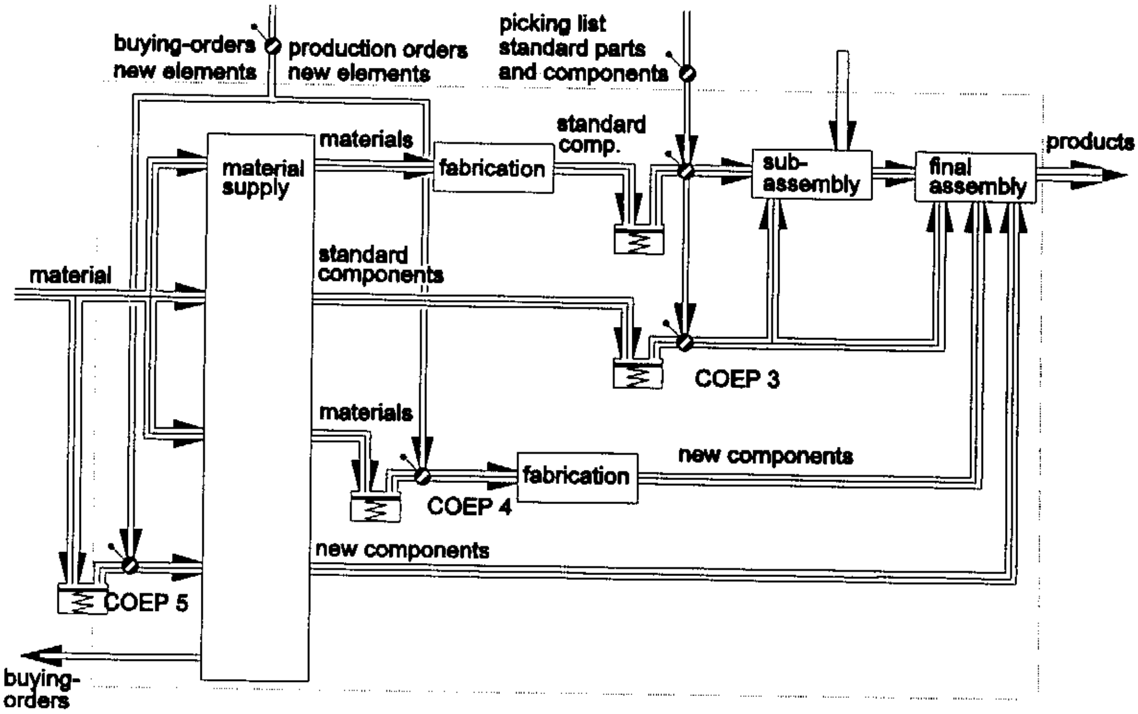


Figure 6: Product realization process

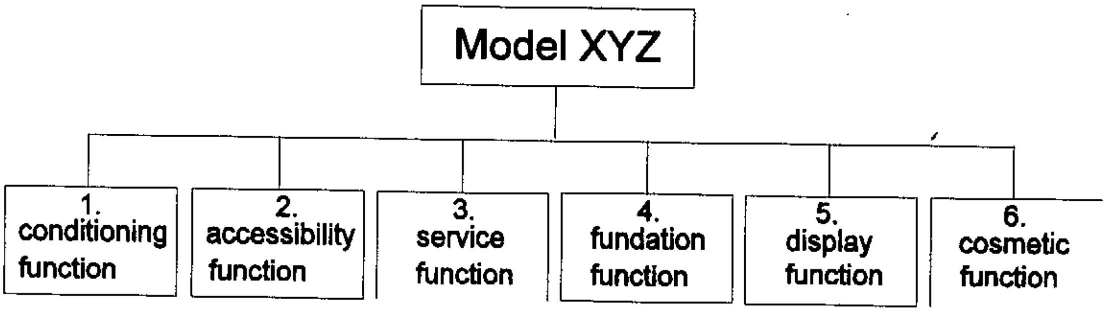


Figure 7: Primary functions of display counters

CONCLUSIONS

Above cases show the successful implementation of the Order Entry Matrix. Not every company wants to change the way of operating nor the systems. First of all, the Order Entry Matrix needs consistent Configuration Management and the adaptation of the organization. The introduction of Configuration Management applies also to changes that have to be registered and controlled to keep all the information and documentation up-to-date. Adapting the organization not only means changing the product structure but also the manufacturing systems and the engineering department.

Companies implementing the matrix and the modules reduce the impact of client specifications by offering a complete range of basic, standard and standard optional modules that will fulfill the clients needs. By configuring the product structure in such a way, the impact of specials on the total performance is as low as possible and then it also improves the OSEP/COEP position.

The results ask for further research into:

- the supporting systems and methods to process the order information:
- the control of the product configuration on the family and order level;
- managing the production flow on prognosis and on order.

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