5. Design Methodology for Building Products

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5.1 Introduction

In this paper the Organogram for Product Development is described for standard products. The Organogram describes in sequential and parallel activities with feedbacks, the main lines of a design and development process for a new standard building product, completed with the necessary marketing phases. In view of the design results, students would benefit more when these and other methods are taught from the very start of their education. The handling of design methods should therefore, as far as it is lacking in the basic years, be brought to that basic training. Not only students need to be educated, teachers also have to become aware of that, in order to make explicit their individual design methods from their subconsciousness and then carry it through to students. Actually three types of building products can be mentioned, separated from each other by the influence of the project or the consumer/project architect, versus that of the product or the producer. In that tense field are: special, system and standard products. Reasoning from the project architect's point of view, who used to draw all component parts of his building himself in former days, this is (extremely put) the sequence of 100% to 0% of influence from special to standard products. From the producing industries' point of view (for instance glass production industries, also working for the automobile industry) the preferential sequence with the intermediate form of products (of which the characteristics also lie in-between the three main lines) is, of course, the other way around: from standard to special products:

- Standard product.
  - Systematized standard product.
  - Standardized system product.
- System product.
  - Special system product.
  - Systematized special product.
- Special product.

The sequence reflects to the producer the sliding down of mass production at a large scale to the workplace productions at a small scale. In view of the normally relatively small serial sizes in the building industry, a much used intermediate station is that of the system products, as greatest common divisors to be put in with more projects and which can be made suitable with relatively little trouble for individual projects in production. The three main types of products have enough different characteristics to scrutinize all of them separately and also to follow a different development process strategy in each of the three cases. Although the following process organizations are very analytical, there is also a holistic vision at the basis. Out of the holism the total is always reflected in the parts. With this is not meant the

connections of parts, but the character of the whole. This influence is especially strong at the synthetical activities like the design synthesis of phase 1 and the research activities of phase 3, by which these will always maintain the guarantee of putting them into the whole.

5.2 Organogram standard products

As a work method to control the entire process, the Organogram for standard products describes the entire process of steps and activities from the initiative up to the actual regular production. The Organogram is a reflection of the sequence of process activities as the author has experienced it as a model for a smooth running process in designing and developing in his company Octatube. These activities, however, are described in a generalizing manner to have a broader validity. The sequence of the various steps or activities is serial (one after the other) or parallel (one next to the other). The specific project circumstances, like the completion of the concerned development project, the capacities and insights of the participants in the process, the time pressure from outside and such worries, cause a different interpretation of any of the three general Organograms up to a specific project Organogram or process Organogram, over and over again. But this does not in the least alter the validity of the Organogram as a general method for product development. Certain sequences are very consciously placed in the shown framing, like firstly Objective and Strategy, after that Evaluation Criteria and only then the working with the Analysis, Brainstorm and Synthesis of partial aspects, then the entire product concept and behind that the evaluation activities. Actually it concerns the sequence of four clusters of activities blocks:

- Objective and Goal.
- Analysis and Synthesis of aspects.
- Clustering for product concept.
- Evaluation and Feasibility.

The order of these four blocks can not be altered, but there is more freedom within the blocks: the partial aspects can be gone through serially or parallel, depending on the subject. Serial working means to be able to concentrate on one single problem at the time, while parallel working means the shoving around of information in one mind, or the simultaneous working of more division groups of process participants. The price of parallel working is a higher complexity in a structured chaos with an inherent loss of costs, the advantage is a more frequent feedback and a faster result. Parallel working is fierce and more expensive, but faster. No more waiting, but anticipating. The increasing demand for parallel working is expressed in the notion ‘concurrent engineering’. We must take into account that principals will want to work through design and building processes ever faster. One of the activities which is hardly to be shortened, is the building permission trajectory. In the beam chart of the entire (preparation and realization) building process the length of the beams of the building permission procedures are hardly alterable. The longer the building permission beams become, the less time is left for engineering and building. In the future the building process will become ever shorter. Concurrent or simultaneously working with all its dexterity to double activities as few as possible, should belong to the intellectual luggage of the engineer.
These types of products are mainly directed at the industrial market and at industrial manufacturing. They are distinguished from the special and system products because the project architect (practically) has no influence on the creation of these products, their manners of production and therefore, the actual resulting product. All he can do is choose: whether or not to apply a certain product. Sometimes minor interventions in the product can still take place per product, like the tangling of bricks, the cutting to fit of tiles or glass plates, but that

is not an influence which is related to the nature or the production manner of the design. The Organogram for standard products is built up of five characteristic phases:

- Phase 1: Design Concept.
- Phase 2: Preliminary Marketing.
- Phase 3: Prototype Development.
- Phase 4: Final Marketing.
- Phase 5: Product Manufacturing.

5.2.1 First phase: Design Concept

The first phase of the Organogram is titled 'Design Concept', and is comparable with a Preliminary Design in architectonical designing. First we will globally explore the steps in this phase before going deeper into each phase. Especially head and tail of this phase, first and foremost deserve our attention.

The Organogram was based upon the entire project being viewed as a 'project'. Logical in activities, but rather confusing in connection with the titles of project architect and product architect. Therefore we will henceforth rather speak of process, instead of project, and in that sense the adjacent Organogram has been adjusted. It is of the greatest importance to correctly define the process objective, the start of the process, the process strategy, the process goal and the evaluation criteria. One could compare this with the importance of a good programme of requirements for an architectural design. If the programme does not meet the actual needs, then much energy is wasted and false expectations are raised which can only lead to disappointment. Firstly, this initial cluster of steps is important because from this the direction the process is heading for is determined and from this the product will be developed in the process. Secondly, it is important to build in the expectation beforehand and the scoring rate afterwards. If the result of the process does not meet the evaluation criteria, the process has failed, unless halfway by a genius turn a consciously different route is taken. When this happens, it is good to realize that the initial goal is not achieved and the goal halfway (that is, after the genius turn) must be adjusted consciously and motivated. It has happened more than once that so-called coincidental discoveries in a research process led to radical results at a worldwide level, while from the original process only an anecdotal mention remained. But this can be looked upon as the exception to the rule that the process must be gone through very accurately. The danger of 'drifting about' in a product development process with all its inherent loss of energy is many times greater and more frequent than the chance of an unintended brilliant side-product. It is a matter of efficiency of human resources.

The end of the first phase must be concluded with the economical step of feasibility, which can also be looked upon as feedback for the evaluation criteria. When this first phase is thus concluded by a positive result, only then the second phase will be entered.

The initiative of a producing company to complete the company's assortment with a new product is derived from the unbalanced relation between changing demands and the set supplies. This new product shout fit in the current assortment, be produced by the existing, available equipment and channelled through existing marketing routes. From this initiative the specific product process comes about.

Start of process: 1

The start of the process is set up by the commission to develop a certain standard product, mostly a material product or also immaterial (like 'virtual') products. The motivation behind this commission can be formed from questions from the practice (= market) for a yet non-

existing product, or an improvement of an already existing product which, by altered usage circumstances is no longer seen as a sufficient answer to the demand. It is also possible that this motivation contains a hidden theoretical objective (for instance in an academic study), leading to a hypothesis without a direct control on the practice. In that case the process must be understood as a product development game, where the end results not necessarily can be or have to be realistic. For instance, the development of Zappi, the famous research topic of tough new and unbreakable structural glass-like material at the Faculty of architecture, TU Delft.
Since, in the case of a hypothetical starting point, common sense and insight are capable, indeed, but personal practice experiences (knowledge) and learning are not capable of making sufficient corrections, it is an absolute necessity to describe and document the process game properly, in order to maintain one's course at this outside world level, in order to communicate with the persons involved in the game. This goes for the student, as well as for the teacher. Well begun is half done. A false start is usually noticed late in time and means loss of energy, much displeasure and friction. The very first question one has to ask oneself at the start of the process and the choice, respectively the acceptance of the product commission, is if this required product is in accordance with the market demand behind it or if it will be so in the future.

Process goal: 2
After the above, the first thing to do in the process is to describe its goal. When it concerns a building, which usually comprises a multiplicity of functions, a programme of requirements describes which functions a building must have. Such a programme of requirements is very extensive for a building. It also changes with time. For the smaller components of the building, however, each of them having less complex functions it will, of course, be simpler.
According to Roozenburg et al (1995) the programme of requirements must in any case mention how many identical numbers of the product must be manufactured, what the price will be and for what market the product is meant. Besides, a design commission has to contain a product basic idea, given by the commissioning company.
Here the question is if the objective or the programme of requirements is set clearly enough, if any inconsistencies have crept in, if there are too personally coloured visions processed in it (that is to say: hobbyism) which would not be just and would lead to a product which somebody may like to see, but would not be a realistic answer to a demand from the market. Enclosed in the company's brief to the designer is the notion that the required product is likely to get a sound receipt at the market. So, this has everything to do with the initial estimating of the characteristics of the product at this point, in order not to become saddled with an unsellable product after the development process. This market notion can be described and controlled by, for instance, making inquiries into a small group of professionals at the very least, or by dedicating a market inquiry on a large scale to it, completed with evaluation reports and a well-reasoned objective of the product. Since the danger of an initial deviation of course in the process, set in at this point and later to be corrected, does not seem hypothetical, it is of the greatest importance to document and elaborate one thing and another, so that afterwards, when there is a correction of course, feedback can be applied. All these activities are the client's responsibility, before commissioning the designer.

Process strategy: 3
Next to the process goal it is good to already map out a route towards the achieving of this goal. Estimated at this stage is how many steps or activities have to be to put in, one after the other or simultaneously. The exact progress of the process is in the dark, but it is good to

make an overall survey before actually starting to work. To students who are confronted with a plan like this for the first time, it is good to set up their own process diagram of assumed steps or activities: their own Organogram. There must be no fear that all steps will not be mentioned or that the emphasis is put on other things when executing the process: the process diagram can be kept up and altered all the time, so that it can serve as a reference book of process management. A second time it will definitely be easier. After this, for instance, the standard sequence will be maintained and from the standard schedule the specific process alterations are brought in automatically. After the first exercise, a certain knowledge should arise in the guidance of oneself and in the reasoning on what activities have to be processed first, followed by what others, respectively what activities must be done simultaneously.
At first sight the alternation of the technique and marketing phases in the Organogram is very striking. To the building technology student it is a clear sign that two marketing phases have been built-in between the three technique phases. To the building management student it is clear that the marketing activities need an intensively developed technical process in three phases to come to a technically suitable product.

Evaluation criteria: 4
The fourth step in the process is already a small running start towards the result, taken by putting down the wishes and requirements a successful product must meet. To set these criteria at this point already, is indeed a precarious matter, because a great advance has to be taken on the process. But it helps to define the exact expectations and when they are expected to be fulfilled. If wished for, returning to this step a couple of times during the process is also possible, as is the well-reasoned adjustments of the evaluation criteria. The pattern of these adjustments also tells, of course, something about the purposefulness of the start and the drifting about of the process afterwards. However, if criteria are not set at this point, it will not be known if the process after having ran through an amount of steps, is the right one or if it will lead to the desired results. Obscure or ill-defined evaluation criteria may lead to simultaneously moulding of expectations and solutions. In the worst case, designers tend to adapt the evaluation criteria to the developed product or process result instead of the other way around!

Process Assurance: 5
As is mentioned above the process consists of a contents part (at the right in the diagram) and a steering and assurance part (at the left). In this process the progress of the process is regularly compared to the previously set process plan, the agreed time schedules and the financial budgets. To this entry consequently belongs a financial estimation of costs beforehand, according to the process and previous experience, from roughly budgeted to, if possible, more refined at set time units, unit costs or total costs. A normal course of events covers the refining estimation of the next steps to follow, up to and including the roughly approximation of further remote steps which, in their turn are being refined from approximation to estimation when the actually processing activities are becoming better known. Since the specific product development process is mostly directly initiated from the company's top management, the reporting of the contents process part is also management directed and the process assuring is a management related activity. The process assurance sets partial goals as well and controls these regularly by watching the actual progress. It almost goes without saying to neglect this financial activity in a study situation, if only a mark-reward did not go with this. Time is essential, even for contemporary students.

Study aspects: 6

After the objective, strategy, evaluation criteria and assurance as conditions have been determined, the core of the process begins with making a distinction in the main problem by a number of partial problems. These are more or less autonomous, or for a short while as autonomously considered aspects of the subject, they can be studied separately. In some processes there will only be a few aspects, in other there will be more. It is clear that with the development of a complex machine or building, many aspects can be studied next to one another, while the designing of a simpler part, for instance a system of new glass blocks, will have fewer aspects. This step also distinguishes the different study aspects in their independence, semi-dependence and total dependence. One thing and another of course leads firstly to the independent study and after that to the combined or integrated study of the distinguished aspects. This hierarchy is later also used again to combine aspects with each other in their interim and final results. After this, the various aspects are given a (identification) number, like in the standard schedule, or they are named. Every aspect is started with the respective (sub) goals and evaluation criteria and, if necessary, also with the aspect strategy. Then the distinguished aspects can begin to be looked upon as clusters, as collections of steps belonging to each other, around a certain aspect. In the following the characteristic steps of each aspect cluster will be mentioned in succession.

Once more: the Organogram looks deceivingly simple, but a process of a complicated product can hold a complex of aspect clusters, which are here marked, for the sake of survey with the first numbers 1, 2 and 3 etc. Each cluster consists in principle of four steps: analysis, brainstorm, ideas, synthesis and the combination of the latter two in an aspect concept. The concepts of the various aspects are then combined into a complete product concept (whether or not after sub clustering in sub product concepts).

Aspect analysis: 7

The first step of an aspect cluster is to unravel the aspect until it has become a combination of indivisible parts, which are studied through literature research, competitive examination, research of existing designs, model research and the likes. In this phase the preliminary product concept is concerned, not yet the final product, so these analyses do not have to be exhausting at this point. It is, of course, also a matter of not losing the overall view, despite continuous feedbacks. ‘Better broad than profound’ is the motto here. Rather process all aspects than leave a few (later perhaps crucial) aspects out for ignorance or unfamiliarity. With the aspect analysis much actual information is gathered as well.

Brainstorm ideas: 8

It often happens in an analysis like this that a kind of research blindness occurs. Apart from this, it happens with every long lasting study. That is why an unceremonious brainstorm step is introduced which, taking distance of the facts from the analysis, enables the designer or students to bring forth all sorts of ideas, ripe or green. The usual tactics then are to have a group of students improvise with each other and lay down all results, with the intention to judge them only later, throw them out if need be, or to combine them. Often such a brainstorm session is necessary to challenge unconsciously living ideas and, with the help of the fearlessness of the one, have them filled up with the responsive ideas of the other. Naturally it also occurs that a step like this can only be taken after a weekend of sailing, or during a long journey when the mind can quietly order the thoughts and is not burdened with all the heavy information of the analysis. Sometimes a spontaneous ‘Eureka’ moment occurs, a flash which also pushes others to go on. At this step the hope of many designers and architects is directed. Not unjustly, because this is where the creativity of the designer has to come from. And there

is always the matrix of the actual analysis which lies at the base of the brainstorm. Brainstorming without a preceding analysis often leads to cycling in the air. Therefore, there is an unsteady balance between conscious and unconscious (or subconscious) steps in this process. Designers are mostly well equipped, compared to many technicians who are hindered by the profundity in which they work in their technical environment.

Aspect synthesis: 9

The factual information and the free flying of the brainstorm session are now being combined by hard and creative work towards a synthesis of the aspect in question. Here an attempt has to be made to give one or more solutions for this aspect. Preferably more solutions, because in the course of the hereafter following combinations many will perish because they will not be compatible with the synthesis of other aspects.

Aspect & Product concept: 10

The results of the aspect studies are laid down in individual aspect concepts. These are now combined with each other, be it in a free form, or in a number of clusters of aspects belonging to each other, or in a tight combination through, for instance, a matrix where each aspect is combined with all the others. This will produce an overdose of combinations of which many will not be practicable, or clumsy, and others perhaps feasible or even very promising. Hopefully, a number of combinations will come up which were never thought of before. It is, of course, a matter of cautious handling of these combinations. All too quickly a disapproval may occur, because it is difficult to recognize the quality of a combination which has never been seen before. From all these combinations it could emerge that the best does not answer to the set total requirements. In that case it is sensible to get feedback with the now acquired knowledge for the starting points, the analysis, the brainstorm and/or the synthesis of aspects, before submitting to this definitively. These feedbacks lead to doing the entire process, or a (major) part of it, all over again. These concentric circles also tend to show a progressive match of the total solution of the problem. It is like swimming around in ever decreasing circles towards the buoy. A good product concept is the factual as well as the intuitive result of studying all aspects, with alternating degrees of success. Designing is looking for compromises.

Technical feasibility: 11

For these reasons it is good to decide now if the resulting product concept is technically feasible. Strictly speaking it must be at this point in the process, as this decision must not be made too early in order to not ruin potentially creative ideas too fast. Of course it requires some ‘enlightenment’ of the reviewer, in order to prevent the feasibility of using one’s everyday spectacles, and having new glasses put in for a change. Perhaps new product techniques must be developed, or raw materials or basic materials may need a different pre-treatment than usual, and so on. It is clear, when in this stage an absolute and final ‘no’ is heard from the production department, and that after repeated explanations and further discussions, the process should be cancelled. If it is, however, not good enough yet, then it is logical to have yet another feedback towards one of the previous activities in order to thoroughly study one of more aspects for alternatives. When the result is positive, only then the next step can be taken.

Preliminary market analysis: 12

The next step is the market, directed to comparing the resulting product concept in the market for which the product is meant (starting point), with the market for which it seems to be suitable (result). Are all the characteristics of the product experienced as being positive? Are

there any favourite and tolerated qualities? What are the attractive qualities? Perhaps market segments, reacting differently to the product, are to be distinguished. If this short feedback of the product concept to the market is positive, or if the client (when known) is positive, then the process can be continued.

Economical feasibility: 13

The last step in the first phase is the financial feasibility. If things were done correctly a global cost-price was proposed in the evaluation criteria. With the help of the proposed production techniques, belonging to the product concept, evaluation is now possible. With technically pioneering products it is not unusual that this economical feasibility step is moved far to the back in the process, simply because many unacquaintances darken the sight completely. In the building industry the sight is mostly obstructed as it is, but yet it is slightly present. The financial allowable margins products must meet is mostly rather limited, since it usually concerns new products which must perform in the same manner as existing products, and those have an actual and known set price. It is like developing an alternative with many set side-conditions. This makes the work sometimes very fascinating, but also hazardous and disappointing. In the case of a complete economical disappointment, the project has to be cancelled. Sometimes hard work must be done to come to a hardly noticeable result. There is no getting out of the way the building industry works with poor materials and low cost-prices per mass, surface or length belonging to that, in order to result in low cubic metre prices of the building practice as a whole. In other cases the products are even concealed and the surplus value is merely the flexible use in time, so in the further away future.

5.2.2 Second phase: Preliminary Marketing

At the very first start of the process a marketing indication must have been given. One does not start a product developing process without further ado. So a global notion of the market attainability must already have been there. This market suitability is also involved in the study at the end of the first phase. Now that there is an elaborated concept after the first design concept phase, it is advisable to first try the concept at the market: is this the product the market segment is in urgent need for? Or does the product perhaps not completely answer to the expectations of the market? Did, on the whole, something maybe go wrong in the first phase, through which a product, as such being very potential, was created for a totally different market than was aimed at? In such a usually expensive product development process a keen eye has to be kept on the goal, as well as on the evaluation criteria. This in order to not get off the track or have a product result which can be added to the average 95% of failures with product development.

It is also imaginable that the activities of phase 2 ‘Preliminary Marketing’ run more or less parallel with the activities of phase 1. Especially when the total of the number of weeks the process is allowed to take up is extremely short, phases 1 and 2 would be possible to pass nearly parallel for those products for which the marketing people know all the routines. Designers must then be mindful that the marketing department will not start to dictate the design department. In general a marketing vision is directed at a short term, where a design vision has to be long term directed. Many designers are not at all amused with marketeers.

Goals: 14

The goal of all activities in phase 2 is to control if the design concept of phase 1 meets the needs of the market, respectively if the product concept has to be adjusted to the requirements of the market. In this phase designers must work together with marketing people of the company, where the help of designers often can be called in to estimate certain architectonical

and building possibilities of the market. For instance, product applications for the various building designs of project architects who operate on the market. Besides, product designers can get, and also take, the opportunity to anticipate on product applications under many different architecture signatures and architectonical styles. By sketching alternative product applications with a piece of transparent paper, on project publications of recent buildings, it is even possible to make an architectonical marketing analysis. Finding applications and recognizing differences in them, naturally requires marketing skills as well as architectonical skills.

Process Assurance: 15
Like activity 5 from the first phase, process assurance enters into the organisational and financial aspects. And here also goes that alert students must handle their time efficiently in order to let knowledge, learning and social education mature.

Marketing analysis: 16
An analysis of the market for the intended product has to be made. How often, under what circumstances can it be applied, in what different performances? Can a distinction be made of different types of buildings or through different offtake channels? Then market segments can be mentioned, each with their own Product-Market characteristics.

Market properties: 17
The market characteristics for which the product is thought suitable need to be described in all their particulars and peculiarities. Distinctions must be made in functional, building technical, architectonical and commercial aspects, and also the approximation of the market, the accessibility, the type of determiners and the determination hierarchy, and the geographical differences per country or countries and continents.

Market segments: 18
The entire application market could probably be distinguished in market segments which, in their characteristics, prominently differ from each other. There will be strong mobile markets as well as more static markets. Market segments are also often to be approached differently among themselves. There will be interesting and less interesting market segments, fast to be conquered short-term markets and slowly to be penetrated long term markets.

Tactics: 19
The various market segments probably know their own determiner, or determination hierarchies. Nature and conduct of these determiners also arrange the most suitable manner to approach the market segment of these determiners, via which route, by which means, people and timing. Distribution and sales channels are also of importance. Tactics will be clearly different for the various geographical market fields. Tactics are the philosophy of approach to get the product to the market.

Promotion strategy: 20
When the different market segments, their determiners and the general tactics are described, then from this follows the strategy to draw the determiners' attention to the product.

Product & Market goal: 21
With this the combinations of types and quantities of products for the various market segments are qualified and quantified, distinguished in short, medium and long terms in time.

Product & Market concept: 22
The characteristics of each desired type of product, in certain required qualities, should be taken to the customers in a specific manner.

Testing product & market concept: 23
The combination of product and market as is set above, is tested for the time being in a small circle of customers, by means of individual presentations, a small group presentation or a presentation lecture, coupled with other events. Do not rouse the expectation yet that the product will soon be available on the market.

Process evaluation: 24
The total process with technical and marketing aspects must be considered as being successful, or maybe there are reasons to adjust it. Other tenderers may have appeared on the market in the mean time. The total need for the new product must be determined at the end of this phase.

Product & Market concept acceptability: 25
The product-market combination should have sufficient potential market opportunities to enter the next technical phase. If not, the process should be cancelled. If not entirely, another feedback is needed again for one or more suitable activities before this step.

5.2.3 Third phase: Prototype Development

Formulation of goals: 26
After the subject of the phase is set, the goal is determined. For example: for study module B3 this means the further designing and developing of the initial concept of the façade scenario up to a prototype on an actual scale, approximately 2 x 2 metres and with the actual materials, manufactured in the workshop by the students themselves. The prototype must be assembled as a technical piece of work. The requirement is added that the prototype is presentable, that it is coated and that a minimum of one glass panel is applied. It must be transportable through access doors and it must fit in a service elevator. At this stage a global description of the goal to be achieved, befits. This description consists of minimal three parts:

- A technical or material part in which the kernel of the product idea is set.
- An economical part in which the required financial achievement is set (numbers, price).
- A marketing part in which the intended market is set.

Process assurance & Financial management: 27
At this point in the process the setting of the financial budgets is extremely important, as there will be much energy involved in all kinds of research activities and development activities, which in themselves are hardly calculable. Involved in this is the investment in time for the product, of persons times the costs of labouring hours. In the total process assurance this activity monitors all the different development activities of phase 3.

Evaluation criteria: 28
A proper programme of requirements is, in fact, a description of the criteria the product will have to meet. Completely different criteria can be summed up per product. The continuous intention, especially at the end of the third phase, is the feedback for these criteria. The criteria can be quantitative, as well as qualitative. It is good to also distinguish stronger demands and weaker wishes. Because a solution which does not meet a demand is not acceptable while, on the other hand, a solution which does not meet a wish, can still be usable. Furthermore, it is important to remember that there is a certain hierarchy in the programme of requirements or in the list of criteria.

Product market identity: 29

A realistic product development does not start just like that, with an imaginary idea. The realistic validity must be analysed. A suiting answer, to the assumed question or a proven problem, has to be found for the product. For instance, for which applications, types of buildings and architecture, for what kind of climatological, functional, architectonical, technical and economical circumstances has such an answer to be found? Do different applications, like market segments, have to be distinguished? To what extent do these division markets influence the qualities of the product? How will the product distinguish itself from existing products which ought to be replaced by it? How would the product finally be introduced at the market? How are the information flows from the building industry? Who are the intended customers, who are the producers, which functions in-between them can steer the usage of the product? By these considerations the programme of demands and wishes is filled up or adjusted. To conclude the provisional marketing phase 2, a market product identity comes about for the time being which provides, as it were, the required image of the product at the desired market segment. This to control that no undesirable products are developed for other market segments which, in themselves can perhaps be very useful. But they leave the original principal empty-handed unless, in the mean time, the starting point has proven to be an unjust assumption. (If such an unintended side-product comes about, then one must document, describe, sketch and store it for possible later elaborations in a different field of study).

Preliminary marketing plan: 30

This will not be discussed here, because it actually comes down to a reflection of the process activities from phase 2. It is, however, sensible to discuss it here if that study does not catch up with this second phase. In the following activities 31 up to and including 37, a number of aspects of the design to be made will be further explored. These activities can take place one after the other with feedbacks, but also simultaneously with strong inter-relations. In any case, each aspect in itself must produce a result which must be brought to a synthesis in activity 38. In general it will not be sensible to choose a material in activity 31, to only study the production possibilities of that material in activity 35, and so on and so forth. All activities have strong inter-relations. Analysis separates the different aspects, but cannot be without the synthesis of once more assembling and combining.

Material research: 31

From the chosen subject and design follows, initially, the research of the most suitable materials. These are compared to one another on aspects such as chemical characteristics, physical characteristics of the separate elements, the components, as well as the capability of combining them. This study is processed simultaneously with the production research and the technical research. The chosen most suitable materials are then once again and far more thoroughly gone over for their chemical and physical qualities. The preference approach is not ‘bottom-up’: starting with the chemical structure, up to the component, but rather a ‘top-down’ approach from the design: by firstly specify the behaviour of the product in question in the shape of a component, then that of the sub components and subsequently to come to the material qualities of these elements themselves.

Technical shape research: 32a

The hierarchy between element, sub component and component must be explored in the shape which arises from a certain material and certain production techniques, to be used for a specific function. Continuous reasoning has to be done here from small to large, from element

to component, from building part to building, and the other way around from large to small. The relation between product and architecture has to be studied in depth at this point.

Technical assembly research: 32b

This is the exploring of the way in which the various elements are connected into a sub component and the way in which several sub components are connected into a component, which perhaps in its turn influences, as a super- component, the shape of the separate building parts, the means and methods of connection and the resulting manifestations. Transport has its influence in the form of limitations of weight and sizes, hoisting points and possible transport reinforcements, while the hoisting crane can also have its influence. Sometimes specific mounting methods can have a dominating influence on the appearance.

Production research: 33

The raw material is usually in bulk and out of reach of the designer, outside the building industry, purified and transformed into material. The material is transformed into usually standard marketable, intermediary products, in professional language normally called 'semi-products' or 'pre-manufactured product' (in the view of the processor, one step before him in the product hierarchy. Metal window-frames are, for instance, called 'basic profiles'. In the case of window-frames there are, fitting in extended window-frame systems, assortments of basic profiles in the available materials of wood, steel, aluminium and PVC. They can be used as a starting point for further development, respectively serve as examples to design and develop an entirely new series of profiles. The question that has to be answered first and foremost is how many running metres window-frame profile of a certain section will be used in the future. For the various materials the material costs and mechanical writings-off with the production of the basic profiles are very different. The ascending line from low to very high shares in the production costs per m1 profile, respectively the economical attainability of small to very large series in wood, aluminium, steel and PVC. These production techniques are about basic profiles. In the further processing of these basic profiles into elements a choice must be made from a number of processing techniques that are specific for the material and for the desired element shape. Although the material is normally strictly limited, the number of processing techniques is large and the number of element shapes (= the result) is, if possible, even greater. But it is ever clear that the product designer draws a great amount of inspiration from the product techniques. Knowledge of the facts is therefore indispensable and essential when new product techniques must be contrived to obtain special process effects. Here, the definite relation between basic material and production techniques and element shape is laid down.

Here could also be considered the various production techniques, as yet unknown to the building industries but surely in vogue with other industries, like car, bus, train and aircraft industries. In mechanical or civil engineering these are: gluing, laminating and casting.

Application research: 34

The three main types of building products, namely: standard products, system products and special products all have a different, yet clear relation with the application of products in the building industry. Standard products can either be put into practice in many applications without alterations, or not be applied at all. System products need a game of question and answer to get their qualities filled in per project. Special products only exist in separate projects. Therefore, the influence of the project architect runs from zero, via partly, to fully. The mentioned main types of products are, to project architects, 'closed', 'half open', or 'open'. Applications, in their turn, can thus have a very penetrating influence on product development. In fact, an amount of technical and architectonical marketing sinks in here, at

the level of the development process. The study of various application environments is in this phase of the project important enough to already give an advance on the multi-launching of the product system, in order to do research on the various locations for the project product. On the other hand, a standard product in a varying context or country environment, can also have an ever surprising effect. Imagine a new car, photographed in the Sahara desert or in the snow. The application research of the ready to hand standard product is seen through the glasses of the product designer on the producing side.

Design prototype: 35a
Out of the combined facts of the designing research activities of phases 34 up to and including 37, follows a prototype design. Perhaps a couple of times feedbacks have to be made for preceding activities (especially the technical research activities, but also the objectives and product market identity are self-evident), extensively described, sketched, further drawn and elaborated at the level of workshop drawings. In this phase (the synthesis) all the gathered knowledge must in a creative manner lead to a design. Remember that most innovations prove to be essentially new combinations of already existing or familiar techniques!

Building prototype: 35b
Depending on the type of product a decision must be made in which form, scale, size and materials the prototype will be built. The prototype serves, in first instance, as a control of the design and development process for the product designer, in second instance as a confrontation model for the market or the principal. Ideally a functioning prototype is made on an actual scale with the intended materials in the manner of the workshop, but to do this in many cases the room, time and budget may be lacking. In that case it is better to manufacture crucial details, or to make a product on a somewhat smaller scale, respectively a form model on a full scale in non-realistic materials.

Testing and evaluating the prototype: 36
In the workplace, the factory or the laboratory performance experiments can now be carried out on the prototype. If the prototype is of an actual size, in actual materials and assembled in a final manner (independent of the fact if it is manufactured by the definite production technique), then it must be possible to carry out a global performance experiment, with sufficient profoundness to have feedback for the functioning of the prototype at design level. Concerning the quality of this test simple devices must be considered, ran through with common sense in a short time. The aim of testing, if it concerns a technically challenging prototype at least, is to be able to view the reliability of the prototype's behaviour with relatively little effort, roughly for 80%. In a more accurate situation (laboratory) the remaining 20% is studied. This usually involves more sophisticated equipment than available in the workshop. After this phase follows, as a rule, a feedback for preceding phases if they do not sufficiently meet the set criteria.

Cost price calculation: 37
Estimating the necessary costs of a zero series, a small series or a large series of identical products after the model of the prototype. Dividing the costs into the costs of the preparation trajectory, the production trajectory and those of the sales trajectory. This is done in order to actually sell the products, to get an adequate sense of these mutual relations. Then a comparison of the resulting cost price + margin = market price with the market price of the intended products to be replaced by the new product. Finally there is the drawing of conclusions, in relation to the financial feasibility at the market, of the new product.

Prototype acceptability: 38
The prototype should answer to the specified expectations and to the specified respects.

Prototype evaluation: 39
The manufactured prototype is evaluated according to the initial evaluation criteria (see activity 31). These are ranged in the order of functional, architectonical, technical and economical criteria. The measure of fulfilling these criteria is set, so is the possible non-fulfilment and the reasons behind this. It will be determined if the prototype will sufficiently meet the specified expectations. Next to that there is also a feedback for the provisional marketing and the product market identity.

Process evaluation: 40
The entire process route is evaluated, besides the individual final results of activity 42. One and another is set and presented by students to module attendants and the external viewers in a, to them, convincing manner.

Approval of progression: 41
In the study situation the study attendance is responsible for the approval of progressing into a next phase. The management of the company for which the product is developed will, on a basis of the technical results from the preceding activities and with a feedback for the provisional marketing phase 2, occupy themselves with the progression of the project. If the opinion is not entirely positive, then perhaps a feedback for further activities of phase 3 may follow. When the approval is granted, the following activities are those of the definite marketing from phase 4. If the management is of the opinion that the process must be stopped, then a reflection on the market position of the prototype product in activity 42 will follow first, before the plan is postponed, put away or thrown away and all costs are written off.

Continuation of marketing: 42
This phase will only be ran through if the management's opinion is that the project has to be stopped. It is to be considered as a summary of the definite marketing activities: are the data of the provisional marketing still correct for the now developed product? For there is a great chance that the technical product development and the marketing plan pulled a totally different track. The marketing opportunities of the developed prototype must be evaluated. This activity does not have to be processed when the management agrees with the continuation of the process, since the fourth phase holds a far more extensive set of marketing activities.

5.2.4 Fourth phase: Final Marketing

After the product is further developed up to the prototype stage, and so physical examples of the product can be shown, photographed or filmed for presentations, the fourth development phase sets in: the definite marketing. In the second phase, with the data of the concept design, there already has been a provisional exploration of the market reaction to the concept product. It is, by the way, not unusual that the marketing phases are not linearly linked after the technical development phases, but are (partly) overlapping, where the danger of marketing pressure and force from the marketing department towards the product development, holds a risk for balanced development. In view of the second phase, 'preliminary marketing', which states requirements, the fourth phase is a more determining one.

Goals: 43
The goal of the fourth phase is threefold. Firstly, the product related activities to definitely determine which possible production methods would be suitable to use (internally and/or

externally) to have the product manufactured. Then the resulting cost price and the final choice of production need to be determined. Secondly, the prototype related activities to definitely determine the marketing opportunities of the prototype product. And thirdly, the marketing related activities to make a marketing plan with a strategy to introduce the product at the market, to have it conquer a place and keep it.

Process Assurance: 44
A budget has to be estimated, time-planning and staffing must be scheduled, as well as external costs be estimated or offered if a part of the activities are executed by others than one's own staff. These activities together form the process assurance of phase 4.

Production techniques: 45
The possible production techniques are now being definitely studied for the component parts, the sub assembling techniques for the joining of elements into sub components and the assembling techniques to manufacture components from elements and subcomponents. Also the transport possibilities and the super assemblies at the building-site, being the mounting, installing and finishing at the building-site, also are a part of this.

Building prototypes for marketing: 46
A number of prototypes have to be built now in order to present them on the market. This must be done in a manner which makes a sensible presentation possible, and which must bring in enough data for a final marketing plan to be based on. The making of presentation material, like photos, videos, presentation folders of the prototype with possible application varieties and sufficient technical support, is part of this activity as well.

Cost-price evaluation: 47
From the data of the most suitable production methods of activity 45 and the required materials and series sizes, a cost price calculation for the product can be set up. The marketing activity 48 will give the reaction to the market price, so that the profitableness of the product can be viewed.

Test market reaction: 48
From the presentation of the prototypes in a physical form or in the shape of images with descriptions, personally (visits), as a group (part of the day presentation in a symposium manner or such) or per branch (exchange introduction), reactions of potential consumers can be recorded. These persons are approached after a hierarchy is set of the route the decisions concerning the application of the product will follow. For instance, firstly the project architect as the determiner of the type of product, then the principal for the sake of the product budget, after that the building costs adviser and possibly a building management office which once more controls the quality and price for the client. After the tendering and contract awarding it is mostly the main contractor who is allowed a semi-autonomous decision as to which of the competitive offers he will agree. He will do so in the knowledge that the architect (sometimes) has a preference and he will be thinking of his own profit position. In this stage the subcontractor or producer are rather often financially squeezed out, without the initial determiners knowing about this, or can do anything about it. To the architect only a management position holds a greater say.

Positive reaction: 49
The marketing test as mentioned in activity 48, which can be processed on various market segments, is evaluated. If an insufficient success is scored, a feedback can take place for the activity in phase 3: which seems the most sensible, or the most probable. If an absolute negative reaction follows, then a reconsidering of the progression of the development project

must take place, or a reconsideration of the market segments and the determiners. Perhaps the manner of presentation has to be altered, or a better occasion must be waited for, in order to create the chance that potential clients can reflect better or more profoundly on this. If the reaction is positive, as is suspected, then activity 51 can be entered.

Choice of adequate production: 50
From the surveys of the most suitable production methods, plus the tenderings and the suitability of side producers or subproducers to perfect the product simultaneously ('co-makers' with technical assistance and high-standing), follows the definite choice of production techniques and production routes. Some of these choices have an artistic design consequence which has to be related to the market reaction, for instance the replacement of a fluently shaped casting by a cheaper, but more angular mechanically manufactured component.

Determination of final product: 51
From the feedback of the market reaction, the cost price determination, the market price determination and the final production techniques, follows the final determination of the product.

Final marketing strategy: 52
Now that the product is final, the market and market segments are known, the routes and hierarchies of decisions have been scheduled, the marketing plan must be rounded off with the marketing strategy. This must map out how, where, to whom, when and with what the product will be introduced to the great (professional) public. The first activities have to be determined, the following ones and the safety net activities when something threatens to go wrong. It must be considered if there will be an introduction at a large scale, or rather a more project directed one, or a 'pilot project' with substantial reductions to ensure the entrance to the market.

Product evaluation: 53
Yet again the definite product with the definite marketing plan is evaluated, in the presence of the management, the technical developing team, the marketing staff, the production staff and anyone who later on must spend their energy to make the product a successful one.

Approval of the management: 54
As a summary of the preceding evaluation, the management will have to give the sign to enter the fifth phase of the actual production. This 'go-ahead' in the car industry holds the starting sign to mostly extended investments. For less specific products, like in general in the building industry, normally the aim is to making the most of an existing machine fleet with a couple of additions.

5.2.5 Fifth phase: Product Manufacturing

Formulation goals: 55
The fifth phase consists of a first production, whether or not directed at a specific project. This is seen as the final test of the technical product, plus the market reaction. Also the definite production of the product (which is ready to be launched after this) is a part of it.

Process Assurance: 56
The financial and organizational management must be accommodated in the regular management tasks of the company in this phase. They should no longer be a separate development process watching. In this phase even the test production is considered to be a part of the factory production, with all aspects connected with it.

First product application (zero series): 57
This activity consists of the production and application of the first, whether or not paid for, test production, which needs to be attended with the necessary care of the technical development team and with the gentle assistance of the marketing team.

Reactions of clients: 58
As a feedback after the first zero series application of the product at an actual scale and in a building, the reactions of the clients are once again gauged and viewed, in order to find if these reactions bring about any alterations in the product-marketing plan.

Production plan: 59
The final production environment is organized as an alteration in the lay-out of the existing production, or only the assembly room is reserved if the production of elements takes place outside and only the assembly takes place inside, or a new facility is being created, with all the architectural, financial and social consequences involved. Location and logistics of production and transport also must be determined in this phase.

Acceptable results: 60
The results of the clients' evaluation of the first zero series application are likely to be positive. If not, the product, the market, the strategy or anything else must be adjusted. It seldom occurs that no feedbacks for preceding activities are needed at this point. However, with a skilfully directed process the 'loops' will be short.

Start of production: 61
The actual production is started with a small and slow running up or an approach at a larger scale if the management and/or clients ask for it. Also this activity will require an Organogram of different activities as such, a discipline which should follow from the discipline derived from the following of this Organogram. The matter will not be further discussed here.

Sale of first application: 62
The contract for the first official commission of an entirely paid-for product. It is open for decision whether or not to inform the clients of the fact that they are the first consumers.

First application: 63
The producing of the first product application shows for the first time all the subactivities which have to be run through to get the product eventually delivered. This single activity 63 consists in itself of dozens of subactivities.

Engineering application: 64
For system products an input of engineering activities will be necessary in order to prepare the product application. For that matter, a different Organogram for system products is in existence, including a system design level and a system applications level. The system application needs engineering.

Production and assembly: 65
The actual production of elements, assembly of elements into components and subcomponents, and the assembly of elements and subcomponents into components. After transportation to the building-site the super assembly, the mounting and/or the installation and the finishing off takes place there.

Alterations: 66
From the first application the need for alterations of the product, the process, the marketing or anything else may come forth.

Improvements: 67
The supplied suggestions are being studied, with feedback for the responsible persons and carried through as improvements of the product, the production process or the marketing.

Start of official sale and production: 68
The official sale and production can now get started via the, in the mean time, set linear organization, the dealer net or whatever route: producer - sub contractor - main contractor - principal.

Launching the product: 69
This is the starting signal for all sorts of activities concerning an adapted publicity campaign and all that is necessary, according to the marketing plan to get the production going and keep it going.

5.3 Conclusion

The previous sections have given an overview of the Organogram that describes the entire process of steps and activities from the initiative up to the actual regular production for standard or new products.

5.4 References

Roozenburg N. F. M. and Eekels, J. (1995). *Product Design: Fundamentals and Methods*, Wiley, Chichester.