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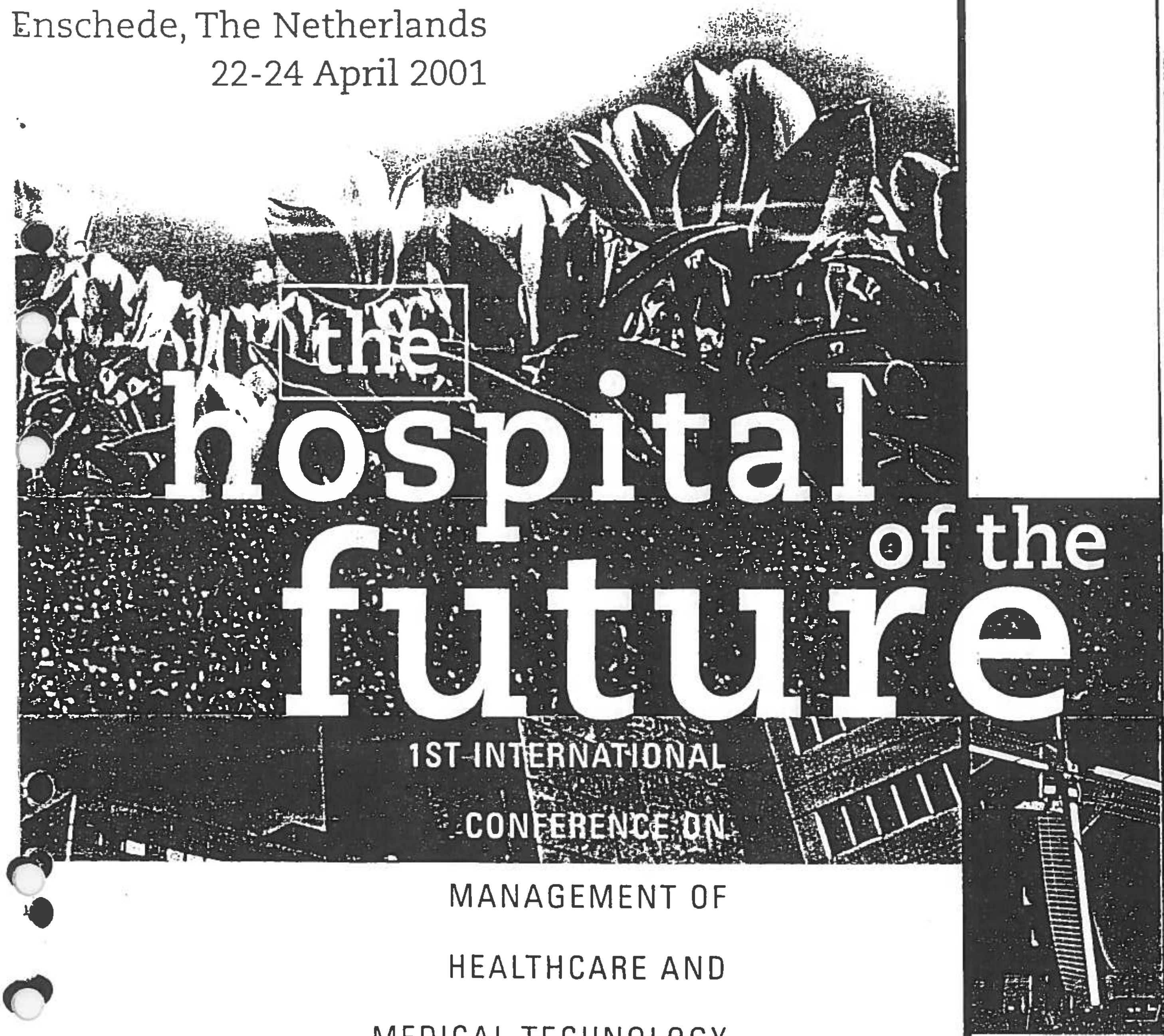

the hospital of the future

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LINKAGE OF USER (TENANT) DEMANDS TO THE (PHYSICAL) BUILDING FACILITY

Reflections on Experiences and Methods from the Automotive Industry and its Implication on Architectural Layouts within the "Hospital of the Future"

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ABSTRACT:

This paper recapitulates selected experiences and methods emanating from the design of a number of assembly systems, as well as give a brief outline of some general principles existing within the automotive industry regarding the organisation of extensive industrial projects. These experiences and methods are embedded in one of the author's professional work, as senior researcher, in close co-operation with practitioners in the Swedish automotive industry during the last twenty-five years.

From this platform, the authors argue and illustrate how to link the (physical) building facility to demands generated by the activities contained within the (physical) building facility. This is achieved by illuminating the linkage of the (physical) building facility to user (tenant) demands through a recommended building design (and construction) process, using a comparison of the health care sector characteristics versus the automotive industry's and the university's characteristics.

To design building facilities, in congruence with user (tenant) demands and to support activities contained in the building, has in fact proved to be intriguing indeed according to the three authors' recent, mutual experiences. This experience concerns design of buildings facilities within the university. However, a building design process in accordance with the principles and praxis used within the automotive industry will result in a recommended building design process, continuously checked at a number of checkpoints ("gates"), defined beforehand. This paper also briefly describes some constructive measures to be used for linking user (tenant) demands to the (physical) building facility. Thereby the authors describe some practical means for design of public building facilities that include health care building facilities.

To conclude, applying principles and praxis from industrial product development processes and assembly system design to the building design process implies the necessity to shift focus from the physical building, i.e. transforming the building functions into a more abstract artefact.

This calls for a more far-reaching product specification of the (physical) building facility, stretching from the initialisation of the building design to the user (tenant) and corresponding to automotive product specification in form of product data included in a product structure. This so-called virtual artefact (product specification based on appropriate product data), that continuously is changing, reforms in relation to a shifting environment and user (tenant) demands.

Not until the input for reformation is monitored and organised in quite another way, than is praxis within the building trade today, will it be possible to create appropriate public building facilities. This will then form one vital ingredient of the "hospital of the future".

1 INTRODUCTION

University and health care buildings are in most cases examples of public building facilities. Thereby they are usually monitored by various sorts of governmental regulations and are thus also closely coupled to a political context.

Two authors' experiences (twenty-five years) from the Swedish automotive industry, concerning principles and praxis from industrial product development processes and assembly system design, have recently been contrasted to the logic of the building trade through experiences common for all three authors regarding three cases of design (and construction) of public buildings within the Swedish university. These experiences are briefly reported below. The third author has experiences (twenty years) concerning design of various public buildings in Sweden, including health care buildings. Some of these insights are also expressed and elaborated in an additional contribution to this conference (Gasslander, Engström, and Wicklund, 2001). The authors' joint university experience has been reported in Engström, et al., (2000).

In this paper the merits of an overarching comparison between branches/trades are underlined. This is especially vital concerning various aspects of the building trade, a line of business which in Sweden has been criticised for producing far too expensive, low quality building facilities, not fully suited for the user (tenant). See e.g. recent criticism in Dahlberg (2001).

By letting the automotive industry and the university act as representative extremes, this paper will discuss the design of building facilities, i.e. hinting at how to organise the building design process in order to establish a linkage of user (tenant) demands to the (physical) building facility. The result will thereby provide insights applicable to e.g. the health care sector.

Example 1:

> The photographs in figure 1, from the Volvo Uddevalla plant design, show the components in a decomposed Volvo 740-model. Each photograph corresponds to 1/8 of an automobile, approximately 1 hour's assembly work. By positioning the removed components beside each other according to position within the automobile body, they helped illuminating the assembly work in a plant where 1/8 of an automobile was assembled in eight separate assembly workshops in series as is schematically shown below in figure 1.[1]
>
> These photographs proved to be valuable when formulating and communicating one of the author's specific work structuring principles and methods. The removed components were for example organised according to detailed product data included in a product structure. In the case of the automotive industry, it was a matter of utilising existing product data from the traditional design-oriented product structure complemented by a newly developed assembly-oriented product structure. The latter product structure is a hierarchical product structure describing the vehicle from an assembly point of view, thus forming a new product specification necessary for radical reformation of the traditional assembly line (Medbo, 1999; Engström, Jonsson and Medbo, 2000).
>
> These specific work structuring principles and methods were used both for the design of several assembly systems as well as for running and maintaining the product data during the full-scale manufacturing, thus forming an unavoidable platform for revision of the product during the operation's (e.g. a plant) total life. In all respects this meant exceeding the building design process time perspective including giving quite

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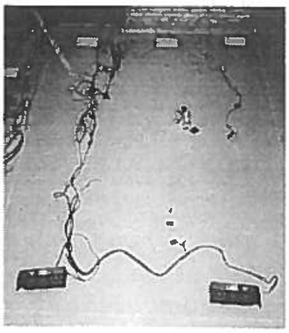
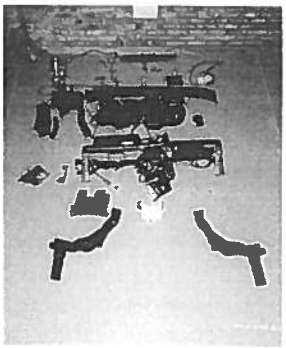
[1] The suggested assembly system design comprised workstation systems with three operators resulting in 20 minutes' cycle time, a division of labour suggested by the manufacturing engineers at Volvo since it was assumed to be the maximum economically viable cycle time (leading to a learning time of 4 – 8 weeks to achieve a work pace of 115 MTM). This made it evident that such a plant would require either large intermediate buffers between each assembly workshop or a constant shifting of operators according to time differences between individual products and product variants; consider for example the components needed for an air conditioner added to the components shown in the photographs. This way the suggested division of labour would imply extra space requirements and system losses as well as a degradation of the product perception by basing it on only 1/8 of an automobile.

another meaning to design and product specification irrespective of whether it is a matter of manufacturing of vehicles or design of buildings.

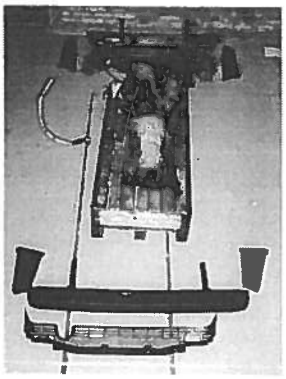
It also ought to be noted that specific labels were fixed to each component representing various product variants and complemented by small paper cards guiding the disassembly. These cards were positioned on the tables next to the removed components and comprised an illustration of the assembly work and the appropriate product variant codification etc. Thus it was possible to shift between the physical products´ components and the product data in order to create a new description of the work being performed within the building (Engström, Jonsson and Medbo, 2001). In the Volvo Uddevalla case, like in others of the authors´ cases referred to, it was a matter of long-term engagement for the researchers during a long period of time (4 – 5 years).



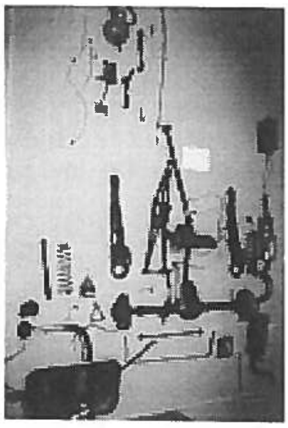
Assembly workshop 1.



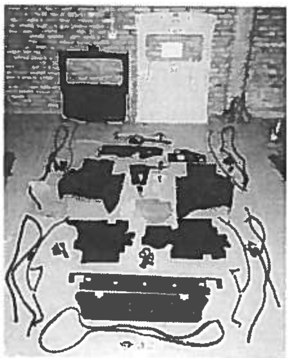
Assembly workshop 2.



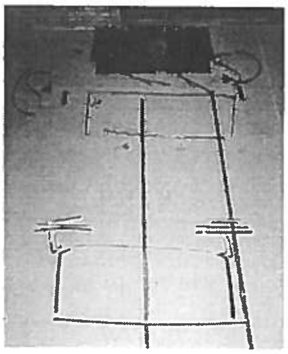
Assembly workshop 3.



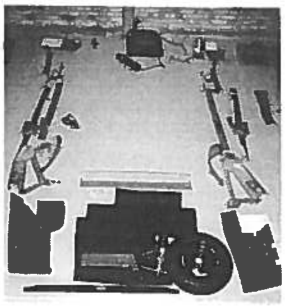
Assembly workshop 4.



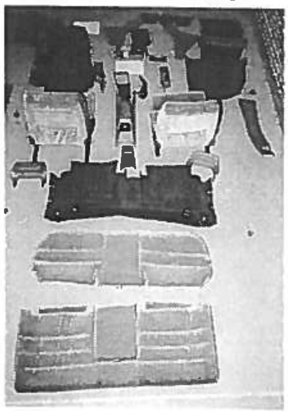
Assembly workshop 5.



Assembly workshop 6.



Assembly workshop 7.



Assembly workshop 8.

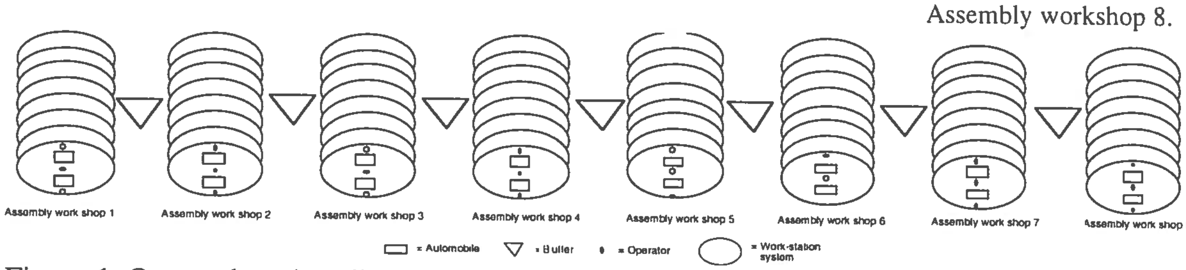


Figure 1. On top there is a disassembled automobile where the components are positioned on the floor according to their position in the automobile body as an example of one specific method for creating a more appropriate product specification, in form of product data included in a product structure. This formed the base for a radical reformation of the traditional assembly line. At the bottom there is an assembly system design schematised where 1/8 of an automobile is assembled in parallel workstation systems holding two automobiles and three operators assembling the components shown above. This practical measure was a practical way of linking the planned activities to the (physical) building facility.

2 THE THREE AUTHORS' RECENT EXPERIENCES FROM DESIGN OF UNIVERSITY BUILDINGS

According to the three authors' experiences concerning the design of university buildings referred to, the importance of user (tenant) participation in the building design process, comprising the process, programme, planning, building and maintenance phases in accordance with figure 3, must be underlined and carried through by means of formalised methods (e.g. Wätte and Cassel, 1989; Bergvist, 1994). Such formalised methods were to some extent used earlier for public buildings during the period when there was an overall responsible governmental authority in Sweden responsible (i.e. The Swedish National Board of Public Building, (Kungliga Byggnadsstyrelsen,). See e.g. Byggnadsstyrelsen, (1979).

The critical function of a correctly designed and utilised building programme, as an integrated part of the more traditional building design documentation, must be emphasised. This programme must be constructed and communicated in the early phases of the building design process and ought to be accepted by all persons involved. Such a building programme constitutes the platform for the later phases of the building design process. It must also be stressed that the building programme ought to include all costs, even those costs that are not directly related to the building in the early estimations included in the planning phase. This might for example comprise costs such as rent for temporary premises for the user (tenant) who has to move around on the campus, cost for lost earnings due to discrepancies in the provision of premises, etc.

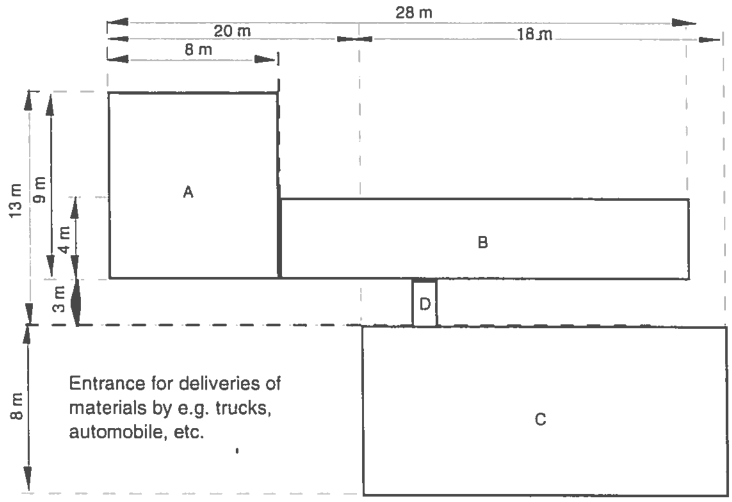
The ways of providing premises within the university are definitely questionable – the recent, mutual experiences from the authors relate to three cases. In each case user (tenant) demands have been neglected and in some cases the user (tenant) has been forced to finance his/her own engineering and architecture expertise in order to have some influence on the buildings projected, all in conflict with the university property manager. This might seem like severe statements, but according to the authors' professional work, involved in several large industrial projects, also embracing the building design process, the adduced design of university buildings deserves criticism.

All these anomalies emanate from the property owner (i.e. the university), whose qualifications as a customer of building facilities have proved to be low. Nevertheless the resulting costs for renting the premises are perplexing (see e.g. Lundholm, 1996). Consequently the extreme rent, exceeding 2 700 SEK per square metre and year for premises which by no means are suited for the user (tenant), is definitely outrageous.

Note that comparable premises rented outside the university would call for one fourth of, up to half, this price). One reason for this is the property manager's (a separate organisation beside the university) striving for universal buildings possible to rent to anyone in the future. A desire, which resulted in non-acceptance of a design of low-cost, less specified premises. This preposterousness has to some extent been circumvented by other means as is exemplified in figure 1. For a more detailed description of these three cases of the idiosyncrasies of building design processes within the university, see Engström et al. (2000).

Example 2:

Layout of the new premises at Chalmers University of Technology, School of Technology Management and Economics; in this case the office and experimental laboratory for Materials Handling Research Group at the Department of Transportation and Logistics. These premises have an internal flexibility which is gained through (1) the combined office and laboratory which could be utilised either as office or alternatively as laboratory or as a combination thereof and (2) possibilities to cut off at various positions along the line from A to C and to create offices form both ends. The use of (3) various sizes of office rooms, in one case a room less than 10 square metres for temporary work and guests, also improves the flexibility. Note however, that this has by no means been a smooth building design process. Still some severe restrictions exist since e.g. the building permit does not allow regular transports to the experimental laboratory.



A = Offices of various sizes from one up to three persons.
B = Combined office and laboratory, i.e. space possible for light mechanical and electronical work.
C = Laboratory for heavy mechanical work but also possible to use as an office.
D = Glassed crossing between the buildings containing offices and the building harbouring laboratories. This was necessary since old buildings were utilised and the vibrations from the metal cutting machines are not allowed to affect the work in the other building.

Layout Codification

Figure 2. Layout of the new premises at Chalmers University of Technology, School of Technology Management and Economics; in this case the office and experimental laboratory for Materials Handling Research Group at the Department of Transportation and Logistics. Laboratory. This layout was, on the initiatives of the authors, from the early phases designed to gain internal flexibility that ought to be considered in other cases. This flexibility, however, was by no means defined in the building programme and was thus not affecting the total building design process except for this specific premise.

3 NOTED DISCREPANCIES AND CONSTRUCTIVE MEASURES

During the adduced design of university buildings the authors have the following experiences worth noting:

1 The existence of time pressure, including intermittent straining of the user resources, which is sometimes utilised by building design representatives who have access to all the detailed information concerning the premises, long-term experiences from similar building projects and a general survey of the specific building project. This advantage is not present for the users (tenants) who is provided with incomplete information and forced to decide under time pressure without realising the consequences of the decisions on their future operation.

2 The occurrence of dimmed responsibilities between building design representatives and property owner (i.e. the university represented by their own Division for Estates and Facilities Management) where some specific decision-makers function (i.e. university board and the headmaster) as customers of building facilities. It is important that the involved responsible personnel and their respective roles are defined in detail beforehand. The building design processes have in two of the cases referred to encountered various critical situations. It has, for example, been unclear what the written commitments required from the user (tenant) in fact has meant and how many such commitments a user (tenant) is supposed to answer. Besides, the building projects representatives have also in all cases neglected to inform the user (tenant) who the actual receiver has been as well as covered up what the consequences would be if the completed (physical) building facility does not fulfil the users' (tenant) requirements. The later aspect is unconditionally necessary to enlighten the responsible persons within the university. This has not been the case during the experiences referred to here. In most cases the appropriate persons from the users' side have not been involved in

the participation process since the responsible persons for research and education activities usually are occupied and since no slack, or designated resources for participating, was included in the building design processes referred to (i.e. in the early cost estimates, included in the planning phase, no such resources were considered).

3 The stiff-legged formalism in the formulation of building functions derived from building design representatives regarding routines and practices, including vague and dimmed overarching directives from the property owner (i.e. the university), functioning as a customer of building facilities represented by their own Division for Estates and Facilities Management which works on the directives of the university board and the headmaster. This is why, as mentioned above, for example lower quality premises have not been considered in the cases referred to. There has been an explicit policy that all rooms should have the same high standard independent of use.

Another peculiarity was the building design representatives' refusal to utilise any form of schematisation of material flow (see e.g. Muther 1961), the lack of specified criteria for exploitation due to communality between various departments etc. as well as not caring the least about aspects like size of entrances, door heights, or loads on floor etc. Only through the initiatives of the users were these vital aspects included in the building design process, in some cases at a phase that is far too late. The resulting costs for renting the projected premises are perplexing. Thus it is strange that the formal mechanism for distributing these costs among the users has not been debated or clarified.

These facts lead to insecurity, i.e. even though it for a long time has been acknowledged that the extreme rent would not be covered by the 10% added to the externally financed research projects, the consequences thereof are still not defined. This might in the near future lead to the fact that departments within the university needing e.g. laboratories have to close down their activities. Alternatively, disciplines requiring substantially smaller premises will be forced to finance activities in need of laboratories etc. Another restriction worth noting concerning Swedish governmental research foundations is that they are not accepting increased administrative costs. Thereby the researchers have to conceal these costs in the calculation when applying for research grants in various ways.

4 The fact that user (tenant) participation and dialogue are carried through by means of insufficient methods based on inadequate information, which means that e.g. the architects have neglected, or been hindered, to clarify fundamental aspects of user (tenant) demands~~, as is praxis during assembly system design~~. The architects have produced assumed layouts without practical relevance and thereby failed to recognise different users' (tenants') varying demands. Elementary demands like the need to bring materials into laboratories and workshops and various aspects of security (e.g. the choice of doors, door frames, windows) have not been recognised. The traditional building documentation, however, calls for expertise to be examined. This ought to be observed if user (tenant) participation is called for.

In all the cases referred to, most of the users (tenants) lacked sufficient insights in what data, according to the building trade praxis and routines, they ought to request for their participation and for formulating e.g. appropriate written commitments. Binders, for example, comprising building permit, building programme, cost calculations, organisation charts clarifying e.g. responsibilities of the building design representatives, were lacking and never asked for by the users (tenants). They did not, by the way, have sufficient experience to understand and survey all the phases of the building design process in accordance with figure 3.

5 The lack of routines for feedback to the user (tenant) concerning how and which building function was insufficient or lacking totally; in none of the adduced cases such an appropriate mechanism existed which continuously secured user (tenant) demands. In one of the three cases such a mechanism was constructed by users' (tenant) initiatives as is explained below, which eventually led to somewhat acceptable premises after a long period of complications and extensive engagement out of the ordinary.

The experiences described above are, according to the authors' experiences, possible to attend to by constructive measures. Otherwise, expensive and costly actions, after the building is completed, will be necessary under time pressure and possibly also result in legal matters regarding, e.g., whom to blame and whom to charge with the additional costs.

Fortunately, the building design representatives usually carry out the actions required if their extra costs are paid, which generally are extremely high in the late phases of a building project. Naturally, the users (tenants) will in most cases not accept to finance demands agreed upon during the planning phase and delays due to insufficient design.

Nevertheless, if this is the case the building design documentation will be very important. It also ought to be noted that the state of the art reported above is in accordance with the observation made by, for example, Statens Arbetsmiljönämnd (1979) twenty years ago.

*

The authors have, with some success, used some constructive measures during one of the cases referred to here. In the other cases some of the authors were consulted during the planning phase leading to the utilisation of some of the measures recommended, while others were neglected by the building design representatives in spite of sharply formulated written commitments.

The constructive measures recommended, and used by the authors, where:

1 The help by professional external support received by user (tenant), i.e. by expertise within the building trade but operating freely outside the building project's representatives engaged by the university. In one of the cases a consultant (university-trained engineer and architect) assisted during a two-year period functioning as a contact between the users (tenants) and the building design representatives; the user (tenant) solely financed him. Due to various reasons it became early during the building design evident that it was important for the users (tenants) to analyse their demands and to have consequences judged or illuminated by various experts. This proved to be the only way to transform user (tenant) demands into building functions.

2 The use of a number of standardised room functions programmes (specification of building functions comprised in various rooms). In these room functions programmes the deviations from a stipulated standard were registered. In none of the three cases referred to were any such programmes provided by the building design representatives.

3 The need for developing a number of illustrative examples and checklists intended for both user (tenant) and the building design representatives, as well as for the top managers within the university not familiar with the logic and details of a building project. In one of the cases, for example, it was necessary for the user to utilise a popular science article describing aspects on electrical security (Carslsson, 2000) in order to illustrate critical knowledge for the building projects representatives which, in fact, ought to be available within a technical university. This topic was debated 18 months before this article posed the problem and gave appropriate references.

4 The necessity to construct a form aimed at the building projects representatives for their own self-control. According to Swedish legislation a formal statement by the official safety representative for a place of work is required before a building is taken into possession. One of the authors was in fact the official safety representative. Thus it was

possible to elaborate a appropriate form which functioned as an official dialogue instrument, i.e. a written statement as a formal self-account from the building design representatives. Thereby various vital anomalies were brought forward, forming the ingredients for after-penetration of specific problem areas by independent expertise.[2]

5 On site inspections by the user (tenant), the inspecting users were supported by their own experts during selected moments of the building design process, the fulfilment of user (tenant) demands were controlled. The results from the inspections were entered in minutes. Concerning selected aspects it proved necessary for the user (tenant) to contact the local building board and other expertise to clarify specific topics and regulations. These clarifications concerned various aspects on which the building design representatives earlier had been vague even though the topics had repeatedly been brought forward. One example is that the sewer of the laboratories called for measures to separate the oil from water. The ethics and the information from the building design representatives proved to be questionable. For example, making statements that easily could be checked by the user (tenant) during various meetings, something that occasionally occurred, did not create confidence.

6 The consideration of safety aspects, which in one of the adduced cases proved necessary to handle in a practical way. After the users (tenant) had moved into the premises, it proved necessary to arrange destructive tests. This activity, comprising six selected objects, was supervised by representatives from the property owner, users (tenant), safety experts from the university, and work environment representatives. These tests illuminated that some of the safety aspects were indisputably inferior. In fact, the destructive tests proved that it was possible to gain access to the premises for six selected cases in 20 seconds up to 5 minutes without setting of the alarm installed. According to agreement with the insurance company a resistance against housebreaking of a minimum of 10 minutes, with conventional hand tools, is required to attain sufficient safety.

This unsatisfying safety was evident even though the building design representatives earlier, during the six months when the premises were used, had asserted that this was not the case. No verification mechanism for acquirement of the defined safety level determined in the building design was regarded. The destructive tests were initiated at one of the authors' (tenant) initiatives. These destructive tests resulted in a written statement defining the object, tools required and time required, combined with video recordings, of which the latter were utilised for dialogues with selected entrepreneurs, responsible for e.g. doors and door frames, glass partitions, locks and locking devices etc. All this entailed e.g. that several doors and doorframes had to be exchanged and that some glass partitions had to be modified (turned around since they were fitted with the screwed rails facing public areas) or substituted.

Some of the authors had tried, but not succeeded, to investigate the blurred relationships between user (tenant) and building design representatives. In one of the cases referred to it was a requisite for the user (tenant) to hire external building experts supported by themselves. Thus taking help from a retired top manager, earlier responsible for building facilities in a large international Swedish company, the only regret was not having done this much earlier. This building design had been going on for one and a half year before this remedy was the only obvious way to at least get somewhat acceptable premises.

[2] This form comprised, for example, questions like: do the building facilities fulfil the adoption requirements for disabled people according to specified laws? Do the building facilities fulfil the legislation regarding recycling of material used in accordance with specified laws? Are there any remaining discrepancies affecting the user (tenant) - planned activities connected to the building facilities, etc. The answers "yes", "no" and "don't know" were fixed alternatives for answering.

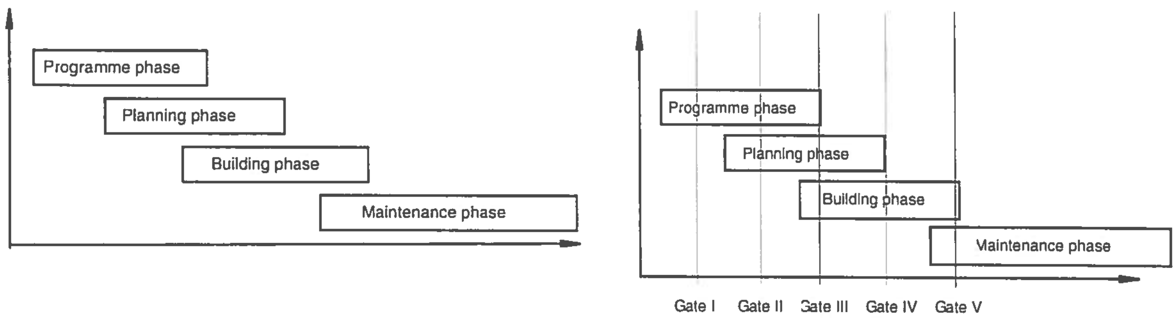
4 SOME ASPECTS ON A RECOMMENDED BUILDING DESIGN PROCESS

It might be argued that some frames of references from the automotive industry have already been transferred to the building trade. For example the term facility management has recently been coined as an umbrella term for various initiatives. However, even though some selected terms from the industry are possible to come across, the profound concept and principles have not yet been recognised within the building trade.

Even though merely the use of terms like product development, according to IVA (1998), has a specific meaning within the automotive industry and is possible to define within building design, this does not mean that user (tenant) demands are fully recognised in practice. It might also be noted that the need for further use of industrial frames of references is brought forward by SOU (2000) which underlines that the term value chains is used within the industry at large but not in the building trade.

Briefly explained, the industrial product development process implies that the assumed product functions are defined, specified and first thereafter split up between designers before the physical product is a reality used by the final customer (i.e. the owner of the vehicle). Intersected between these activities a number of "loops" occur, which comprise both digital and physical mock-ups and prototypes used for verifying the linkage between user (tenant) demands and the complete product on the market.

Even after the point of time of marketing then the product is owned by the final customer), the product specification in form of product data included in a product structure, is cherished. This product structure forms a platform for implementing of product (design change orders), and introduction of new product variants. As well as for exploitation of carry-over components, "securing" various legal aspects of the product (in the case of vehicle in form of e.g. safety and emission standards) etc. These are procedures that are in contrast to the building design process where the building design representatives leave a specific building design in order to repeat the procedure elsewhere, thus leaving the user (tenant), and the property owner, alone in the completed building facility.



The phases in a building design process according to the three authors' experiences.

A recommended building design process.

Figure 3. The building design process, comprising the process, programme, planning, building and maintenance phases must, as is the case in extensive projects within e.g. the automotive industry, continuously be checked by a number of checkpoints ("gates") defined beforehand. No further work within the building design ought to proceed until the agreed criteria at the checkpoints are fulfilled (se Sundsvik, Höjer and Mellander, 1983; Engström et al., 2001).

This comparison implies the need for a more far-reaching product specification of building facilities stretching from the initialisation of the building design to the user (tenant). However, there are some similarities with principles and praxis from industrial product development and assembly system design, i.e. a recommended building design process, guided by a correctly designed and utilised building programme, since there will be a number of checkpoints ("gates"), defined beforehand (see figure 3). These "gates" correspond to what, within the automotive industry, is denoted product and process verifications.

This is a procedure that has been utilised within the building trade in Sweden for environmental aspects due to building design and choice of materials as defined by Bergqvist and Rönn (1999 and 2000) in accordance with the so-called environmental manual for the building sector used by the building trade (Miljöstiftelsen för Byggsektorn, 1998). See Bergqvist and Rönn (2000).

The verification process that is sketched in figure 3 is by no means unknown within the building trade, since in Sweden the responsible management, according to legislation, is forced to participate with the employees during e.g. reformation of premises. However, this is usually carried through as a restricted user (tenant) influence, verified only once during the building design process, namely at the moment when the building permit is considered during the building phase. This dialogue is in most cases a matter of juridical interpretations of the work environment legislation (Bergqvist et al., 1989) and not a broad, detailed and long-term user (tenant) engagement as is described by Ahlin (1980), Bergqvist (1994), Rönn (1990), Ranhagen (1980) and Steen and Ullmark (1982). Accordingly, there are, in fact, elaborated routines and praxis available for a qualified user (tenant) influence and dialogue. Such formalised methods, in some cases providing possibilities for long-term user engagement, were to some extent used earlier when the governmental authority (Kungliga Byggnadsstyrelsen) in Sweden was held responsible for governmental buildings (see e.g. Byggnadsstyrelsen, 1979).

To conclude, in the light of the authors' recent experiences and the literature references mentioned above and elsewhere in this paper, the problem areas of user (tenant) participation within the building trade have not, during twenty years, been rectified. This is a fact even though knowledge as well as insights is easily accessible as is evident by the references.

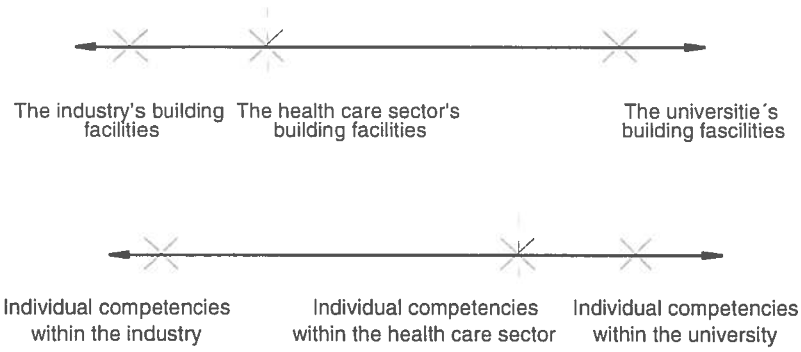
5 CONCLUSIONS

This paper has described and recapitulated experiences from three projects regarding design of public buildings, which are fully in line with insights gained by the third author from the design of health care facilities. The three adduced cases, which collectively, in various ways, have involved all three authors have been compared with experiences from the automotive industry, (thus) underlining vital facts concerning the building design process and the building trade's principles and praxis.

Some kind of more detailed comparisons between the building trade and the automotive industry, as well as generalisation, is called for to thereby contrast two diametrically different positions, i.e. the logic of the building trade and the logic of the automotive industry respectively, each of which might be regarded as representative extremes. In addition, if the argumentation, brought forward above, should be further detailed, the health care sector's facilities might be assumed to fall somewhere in between these extremes.

On one hand, focusing on the materials flow aspects of "health care products", whatever this might be, the health care sector's building facilities are more connected to the automotive industry since, obviously, complex flows of "products" (various materials, different categories of employees, clients etc) are passing through the buildings. On the other hand, the university does not have such a discernible flow of "products" and definitely not the same demands for a detailed synchronisation of various activities as the health care sector and the automotive industry. The eventual consequences of lack of fulfilment of the stipulated goals and agreements are not as obvious, or demand immediate actions from the employees or management, as is the situation within the health care sector or the automotive industry.

Consequently, the impact of user (tenant) demands on the (physical) building facility might for the health care sector be assumed to resemble the conditions in the automotive industry rather than those at the university (see the top of figure 4).



The health care sector's building facilities and individual competencies versus the automotive industry and the university.

	THE AUTOMOTIVE INDUSTRY:	THE HEALTH CARE SECTOR:	THE UNIVERSITY:
SOME PRODUCT DEVELOP-MENT ASPECTS:	– Extensive long-term formalised product development work the responsible organisation.	- Some long-term product development work within the responsible organisation (e.g. research work).	- Delimited formalised product development work within the responsible organisation.
SOME PRODUCT SPECI-FICATION ASPECTS:	- Defined far-reaching product specifications (i.e. product data included in a product structure) not communicated outside the responsible organisation.	- Some far-reaching product specifications exists which is communicated both inside and outside the responsible organisation.	- Lack of product specifications in the true sense.
SOME ASPECTS ON THE PHYSICAL PRODUCT:	- Numerous deterministic standardised physical products (vehicles)	- Quite many, both stochastic and deterministic, non-standardised products (i.e. patients)	- Some deterministic standardised virtual products (e.g. courses).
SOME ASPECTS ON FLOWS	- Defined materials and product flows.	- Complex mixed discernible materials flow.	- Lack discernible materials flow.
SOME USER ASPECTS:	- User of the product (i.e. customer) well defined and cared for.	- User definition (i.e. patients or employees: extensive but heterogeneous	- User definitions on numerous "products" (pupils) are defined while other user (employees) are less carefully defined.
SOME PRODUCT LIFE CYCLE ASPECTS:	- Far-reaching product life cycle responsibilities.	- Far-reaching product life cycle responsibilities.	- Delimitation of product life cycle responsibilities.
GENERAL COMMENTS:	- Private sector. - Influenced by politics in the long-term perspective.	- Public sector - Heavily influenced by politics in the short-term perspective.	- Public sector - Heavily influenced by politics in the short-term perspective.

Figure 4. Summarisation of comparisons of the health care building facilities versus the automotive industry and the university (at the top). Below in the figure there is a table comparing the health care sector characteristics and the automotive industry's and the university's characteristics, regarding the aspects of product development, product specification, physical product, various users and product life cycle aspects. This comparison might be debated as well as further examined in detail. However, it illuminates a procedure to condense the point of views and insights presented in this paper.

However, if the point of convergence is the individual person's competence (operator in the automotive industry case) then the health care sector bears more resemblance to the university (the training and learning times required to become a professional is a matter of decades, depending on personal interests and ambitions). The automotive industry, on the other hand, has by tradition been striving for a delimited work content requiring low competence for most of the total work force (see the top of figure 4). However, there are some evident exceptions, as mentioned above, but they are, in fact, neither fully recognised nor fully understood by most practitioners.

Note that this paper does not refer to earlier principles and praxis, advocated by the automotive industry, like extensive mechanised and automated equipment and automated guided vehicles systems (AGV-systems). For example, these AGV-systems were, according to the experiences of one of the authors, and still are, a technical fad not usually considered within the automotive industry to the same extent as (was the case) twenty years ago when, e.g., such a system was introduced at Östra Sjukhuset in Gothenburg.

The authors point at a "new" not yet fully crystallised manufacturing engineering knowledge, i.e. principles and praxis where the so-called virtual artefact (product specification based on appropriate product data) is designed in congruence with the physical artefact (materials feeding technique, layouts, the choice of equipment and tools etc). This was the case for an assembly system design touched upon above.

The insights from industrial product development processes, on the other hand, also imply the general need for utilising a more far-reaching product specification within the building trade, which in turn is applicable to the health care sector. It is far-reaching in the respect that it stretches from the initialisation of the building design to the user (tenant). This is a product specification that, like in the automotive industry, continuously reforms in relation to changes in environment and user (tenant) demands. The input for reformation has to be monitored and organised in quite another way than today, which is praxis within the building trade, in order to create appropriate public buildings.

Industrial product development processes involve supplying a number of specific functions, as an answer to user (tenant) demands, in form of primarily building functions and secondary auxiliary functions.[3]

These functions ought to be continuously evaluated, preferably by defined methods during the (physical) building facility's total life, a procedure that must include the users (tenants) and employee's points of view. This might be a constructive future development of the coined umbrella term of facilities management.

However, if practitioners and researcher accept the approach implied in the comparisons with industrial product development processes by specifying various building functions, they must also accept that it is also complemented by determining the auxiliary services furnished by the property manager or other parties.

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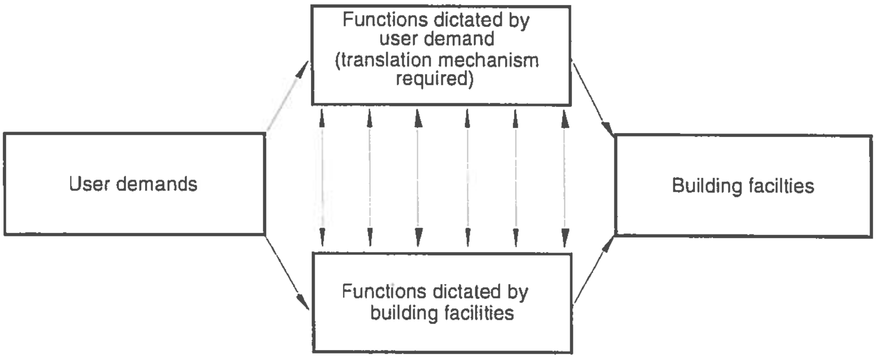
[3] In accordance with of reasoning above concering specifying the building facility might roughly be expressed: to primarily furnish the specified functions of climate- controlled work places to a specified number of employees, which in turns requires lighting, electricity, external- and internal communications, admitted separation of various defined categories of waste, permit of a specified safety and security aspects, appropriate specified interfaces in relation to the user (tenant) in form of e.g., materials supply of defined items, telecommunications, etc.

Traditional procedure



Recommended procedure

Figure 5. The figure schematises traditional procedure and recommended procedure, how to link the (physical) building facility to demands generated by the activities contained within the (physical) building facility.

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Summing up, applying principles and praxis from industrial product development processes and assembly system design to the building design process implies the necessity to shift focus from the physical building. Thus the building functions are transformed into a more abstract artefact, (i.e. a so-called virtual artefact based on appropriate product data).[4] This is an artefact, which continuously is changing – reforming in relation to various changes in environment and user (tenant) demands. Input, which must be monitored in quite another way than today, is praxis within the building trade, and not until then is it possible to create appropriate public buildings. Accordingly, this will create a new platform for the "hospital of the future".

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[4] This concept might be coined "conclusive product development".

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