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THE "INDUSTRIAL PRODUCT" VERSUS THE "FACILITY PRODUCT" – A framework for crystallising the health care services of tomorrow"

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Abstracts:

The building design (and construction) process for public building facilities, such as health care building facilities, is a complex process. The practices and logic employed by the building trade regulate this process with questionable results. One approach that could be used to help avoid the sometimes unfortunate results of such a traditional process is to take advantage of experiences from other branches of industry. However, in order to be successful, this method demands a way of generalising that will retain the specific details and characteristics of those different branches. This paper focuses on the above-mentioned generalisation process by discussing what we call the "facility product" and the "industrial product" and how they apply within their respective professional contexts. Experiences gained from the examination of other aspects of industry, especially various product development processes, underline the different practices and logic employed. For example, the process of defining and integrating user (customer) demands, combined with carefully monitored resources and costs, has in most respects no equivalent within the building trade. It may be argued that the industrial mass production process is not applicable to the design of customised buildings. This statement might be true to a certain extent, but the mirroring of practices and logic is likely to bring to light the potentials as well as the discrepancies in a way that would otherwise remain unexplored.

1 BACKGROUND

The building design (and construction) process (comprising the planning, building and maintenance phases) of health care facilities is a complex process. By tradition, the practices and logic employed by the building trade regulate this process with questionable results. One approach that could be used to help avoid the sometimes unfortunate results of such a traditional process is to take advantage of experiences from other branches of industry. However, in order to be successful, this method demands a way of generalising that will retain the specific details and characteristics of those different branches. This calls for linking the discourse to the ongoing design paradigm and design criteria within the branches involved.

The restructuring of the healthcare sector in line with the technical development is also dictated by lack of appropriate personnel resources. This fact will, in the future, further underline the need for a non-traditional way of organising the building design process. This will, in turn, affect the services provided by the so-called core business within the healthcare sector, which are mainly carried out by doctors and nurses. The patients' insights regarding medical matters are gradually improving. At the same time, various achievements are taking place in the field of science, such as an accelerating development of computer based expert systems supported by various distance communications systems (i.e. telemedicine). The patient's role will be transformed in future with patients contributing, to a greater extent, to the services provided (this process of change might humorously be termed "seeing your doctor by remote control").

To keep up with this accelerating process of change, new approaches to supplying appropriate building facilities for the core business are needed. This will obviously, in turn, affect various existing and new auxiliary support functions, leading to totally new organisational and technical interfaces being defined.

It is the aim of this paper to contribute to this process of change by utilising other branches as a comparison, namely the automotive industry, which might function as a catalyst. This comparison will involve the traditional building design process as such as well as give an outline of some characteristics of the "facility product" of the future, as applied to the healthcare sector. All this is in many respects a process change that has already been started in Sweden.

The authors' recent experiences concerning participation in the building design processes of university buildings underline the need to transform the traditional building facility (the "facility product") by means of established industrial product development methods into a more advanced product. It will thereby be possible to define yet another product for analytical purposes, namely the "industrial product".

The healthcare sector in Sweden is also affected by the anomalies where user (tenant) participation during building designs has encountered extensive resistance. See Henriksson, Gardell and Mächs (1983) or Gustafsson, Carlsson and Henriksson (1991). In none of the cases reported in these studies was the researcher able to identify any example where the responsible official decision-makers had reformed their formal decision procedure in accordance with the healthcare personnel's time-schedule (Gustafsson, Carlsson and Henriksson, 1991, p. 161). To summarise, in Sweden substantial resources have been invested in various forms of participative initiatives within the healthcare sector. Unfortunately, however, these initiatives have not proved especially constructive.

The newly popularised term of facilities management[1], which is a reorientation of the building trade (and thereby the healthcare building facilities), may, or may not, be used to denote this transformation of the "facility product" that has become more or less a necessity due to circumstances dealt with below.

2 AIMS AND DELIMITATIONS

This paper focuses on generalisation by discussing the "facility product" and the "industrial product" in their respective professional contexts. In this respect it should be noted that the Swedish government has recently approved the term "value chain" as a constructive concept for the recent development within industry. This development was hardly something that the building trade had anticipated (SOU 2000). Thus, the exploration of the "facility product" by means of industrial references is only in its infancy, even though there are a few examples. See e.g. Bergqvist and Rönn (1997) or Holmberg (1995).

On the other hand, experiences from industry, especially those from various product development processes, shape a different practice and logic. There, the process of, for example, defining and integrating user (customer) demands in the process, where resources and costs are carefully monitored, has, according to some of the authors' experiences, in most respects no correspondence within the building trade (Engström, Bergvist, Gasslander and Örtengren, 2000). It may be argued that the industrial mass production process is not applicable to the design of customised products, such as buildings. This statement might to some extent be true. However, the mirroring of the practices and logic of other branches is likely to elucidate potentials as well as discrepancies in a way that would otherwise be unexplored.

Thus, the authors will compare the two branches mentioned above at both general and specific levels. This, in combination with the restructuring of the healthcare sector, briefly touched upon above, implies a new infrastructure of various healthcare facilities that exploit telemedicine and information technology.

[1] Facilities management represents the extended service that e.g. a responsible facility manager can give the users. The name has much in common with the content of the different phases within a traditional building design process that are described by e.g. Wikforss and Lundequist (1996). See also e.g. Svenska Kommunförbundet (1998) for one definition of facilities management.

3 INDUSTRIAL FRAMES OF REFERENCE

The frames of reference referred to in this paper concern industrial product development and, to some extent, also assembly system design. These frames of reference could, in the local research context of the authors, be seen as amalgamating various aspects of manufacturing, in order to link the production system design to the building facility. Such an approach has been treated by e.g. Granath (1991) who has, for a selected number of cases, studied the linkage between production system design and building facility design.

However, the most spectacular and far-reaching industrial restructuring referred to in this paper concerns the use of a specific design procedure that has been refined and used by some of the authors in five cases within the automotive industry. This work involved long-term co-operation between industry and university (Engström, Jonsson and Medbo, 2000). In most of these cases it has been a matter of design of unorthodox assembly systems. These assembly systems comprised parallel product flow, long cycle time assembly systems, which are the opposites of serial product flow, and short cycle time assembly systems (i.e. the traditional assembly line).[2] These insights are scientifically proved and empirically validated, but not yet fully internationally established (see e.g. Medbo, 1999).

On the other hand, the frames of reference regarding industrial product development processes represent knowledge that is well established within international industry. See, for example, Olsson (1976) or Pugh (1990). These need, however, to be complemented with one of the authors' professional experiences concerning industrial product development of professional products (articulated vehicles and sawmills). These insights comprise methods for, e.g., the procedure to pass a product through the phases of product development, production, purchasing and marketing. See, e.g. Olsson (1976), Andreasen and Hein (1987) and Ulrich and Eppinger (2000). A further recognition of the user (customer) demands having an influence on industrial product development processes (user controlled product development) is focus groups. Such groups have, for instance, been used for developing vehicles for public transportation, including vehicles for distribution of goods within a city (Warsén, 1996).

In short, the product development process within the industry comprises allocation of defined functions to the physical product, which in turn will create functions recognised by the user (customer). This means that, in order to be fulfilled, functions and services have to be specified and some of them allocated to services provided by professional personnel. In some cases, a product might consist, mainly or solely, of provided services. In this case it might be suitable to talk about a "service product" (Grönros, 1997).

4 CHARACTERISING THE "FACILITY PRODUCT" OF TODAY

Applying the introduced industrial frames of reference on the building facility makes it possible to recognise the "facility product". In a narrow sense, this may be interpreted as allocating defined functions to be fulfilled by selected building functions that are created by the building facility.

However, apart from supplying the appropriate building facilities for the core business, it is, in a broader sense, necessary to recognise the need for various forms of support functions for the "facility product", along the lines of the practice already established within the industry. As mentioned above, this fact calls for the definition of new organisational and technical interfaces.

Generally speaking, for the user (tenant) of the building facility, the definition of the product as such in the form of the physical building has for a long time been unclear. This situation is, according to some

[2] The introduction of unorthodox assembly systems called for a reformed product perception by operators and engineers. This proved possible to achieve by reforming the product information, which was already available in the traditional design-oriented product structure, and complementing it with data regarding the existing product and the manufacturing process to create an assembly-oriented product structure. This reformation is an essential requirement since it facilitates the design procedure and promotes the introduction of e.g. non-traditional materials feeding techniques (i.e. it is necessary for the function of the new assembly system to communicate with the traditional design-oriented product structure). See e.g. Medbo (1999), Engström, Jonsson and Medbo (2000) or Engström and Medbo (2000).

of the authors' experiences, a distinctive feature of university buildings. This situation is basically due to a deficient dialogue between user (tenant), the persons responsible for the specific building design and the university's property manager. All these idiosyncrasies emanate from the property owner (i.e. the university), whose qualifications as a customer, responsible for defining the building facilities, have proved to be poor. Nevertheless, the resulting building costs are perplexing (see e.g. Lundholm, 1996). Verification processes comprising user (tenant) participation are, according to some of the authors' experiences, rare. Generally speaking, the design of public buildings in Sweden is hampered by shortcomings. This especially concerns the dialogue between persons responsible for investments in building facilities (Oresten and Löfvenberg, 1998).

	THE "INDUSTRIAL PRODUCT":	THE "FACILITY PRODUCT" OF TODAY:
Market characteristics:	- Market research is mostly carried out. - For consumer products, strong competition exists. - For professional products and complete production systems there is an oligopoly situation.	- Delimited market research is carried out. - An oligopolistic situation or most commonly a monopolistic situation.
Product development characteristics:	- Fast product development for consumer products. - Slower product development for professional products and commodities.	- Slow product development since driving forces are mostly lacking - Rational and systematic methods for product development exist but are mostly not used.
Product verification characteristics:	- Very complex and time-consuming product verifications which are regularly carried out. - The user (customer) takes part directly in the verification process even in the early phases.	- Verification processes comprising user (tenant) participation is rare. - The user (tenant) does not always take part in the early phases.*

* 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 has to be recognised by all persons involved (see e.g. Steen and Ullmark 1982).

Figure 1. Some comparisons between the "industrial product", as is the tradition within industry, and the "facility product" of today, according to practice within the building trade regarding market, product development and product verification characteristics. The table above might be questioned in detail, however, it illuminates the intriguing problem area of defining various key terms in both the long and short time perspective, respectively. For example, the customer of an automobile will consider, among other things, the trade-in value of the vehicle. On the other hand, the user (tenant) of the "facility product" must consider the future reformation of his or her activities in a somewhat shorter perspective than the property owner. The comparison between the two "products" above also underlines the difference in time perspective between the two branches involved; such as that the product development phase of vehicles comprises e.g. 3 – 6 years, after which it may be marketed at a profit for a period of 5 – 10 years. The building design process represents a marginal part of the building facilities' "profitable life".

This fact could be illuminated as follows; a customer seeks to obtain a product that satisfies his or her demands. The building facility of tomorrow (including various associated installations) therefore needs, to a larger degree than today, to be modified to meet even more shifting demands due to changing activities of the user (tenant) and other circumstances not dictated by the user (tenant), such as various political processes, i.e. changing "political contracts". This implies possibilities to increase the profit generated by the "facility product" as well as for the core business of the user (tenant), since the user (tenant) only demands to purchase specific support functions needed during a specific period of time.

Thus, the building trade of the future will most certainly be transformed from a monopolistic to a more oligopolistic situation. The future development of the "facility product" will thus have much in common with industrial product development processes. However, since the "facility product" also contains extensive elements of service supplied to professional users (tenants), an accelerating development of the service dimensions will take place. This accelerating development will specifically be applicable in cases where the professional user (tenant) is prepared to invest their own resources in the early phases of the building design process. This insight has, according to some of the authors' experiences, not been prominent during the design of university buildings.

According to one of the author's experiences regarding assembly system design, the most far-sighted developer of the "facility product" must recognise the need to refine their knowledge by using various forms of documentation beyond the traditional design documentation.

This type of product specification of the building facility is far-reaching, stretching from the start of the building design to the user (tenant) occupying the building. It corresponds to automotive product specifications in the form of product data included in a product structure (as discussed in another contribution to this conference, i.e. Engström, Berqvist and Gasslander, 2001).

5 EMERGENCE OF THE "FACILITY PRODUCT" OF THE FUTURE AS APPLIED TO THE HEALTHCARE SECTOR

There are obvious similarities between the industrial product development process and the development of new healthcare services. They both contain concentrated activities during a given time with a given set of objectives, where a number of persons with expert competencies in a structured way develop a product with a given methodology.

Professional personnel responsible for developing the "industrial product" have a role that is similar to their counterparts in charge of healthcare service development. This is especially evident when the industrial product development process comprises so-called user-friendly products. Note also that it is in fact a layman that is the consumer of the healthcare services, which is also true for the "industrial product" in the case of consumer products.

According to the authors' opinion, one of the merits of applying established industrial product development methods within the healthcare sector, such as focus groups, is that this will probably legitimise the restructuring briefly discussed in section 1. A similar analysis for the healthcare service of the future, in accordance with the "service product" is also possible to carry through. Here, of course, certain unique characteristics have to be considered like privacy, personal integrity, ethical circumstances etc. See e.g. Eriksson (1987 and 1988).

To summarise, the healthcare sector of the future has to restructure. The work to accomplish this may, or may not, utilise industrial frames of reference. If these references are put to use, they will probably legitimise the restructuring as will, of course, various achievements in the field of science. However, this process of change will, most certainly, also contribute to a much more inclusive definition of the healthcare services. It should be noted that some of the ideas and concepts brought forward today are by no means new. For example, the healthcare service that is specifically aimed at the patients is described by e.g. Graf (1965), focusing on reduced queues, while Petersson (1964) concentrates on "the patient in focus".

DESIGN CRITERIA TO ACHIEVE DEFINED. FUNCTIONS:	ESTABLISHED METHODS APPLIED FOR THE "INDUSTRIAL PRODUCT" OF TODAY:	SOME CHARACTERISTICS OF THE "FACILITY PRODUCT" OF THE FUTURE AS APPLIED TO THE HEALTHCARE SECTOR:
(I) Internal communication and relationships within the organisation:	- Product managers appointed that are responsible for specific products or product families. - Specific education and training at the marketing and manufacturing departments in accordance with the product specification.	- Facility manager appointed that is responsible for the total building facilities/facilities supply. - Facility staff training and education in accordance with corporate policies and contract specifications.
(II) External communication and relationships between the organisation and user:	- Focus groups that articulate the user (customer) demands as mentioned above. - Test marketing in order to measure and verify user (customer) acceptance. - Market research and market estimation in order to measure the market potential.	- Focus groups that articulate the user (tenant) demands comprising professional personnel e.g. doctors and nurses as well as patients.
(III) Product design process:	- Function analysis in accordance with so-called integrated product development as touched upon above. - A comprehensive specification of demands, which is a consensus of the design, manufacturing, purchasing and marketing departments, and which includes user (customer) demands and environmental restrictions.	- Function analysis in accordance with so-called integrated product development. However, this analysis must also include implications from the political process, i.e. a "political contract". - A comprehensive specification of demands, which is a consensus monitoring a defined interface between the facility manager and the user (tenant).
(IV) Efficiency due to factors such as costs, space utilisation, maintenance, etc. which is an effect of I – III mentioned above:	- Achieved by means of so-called value analyses, i.e. cost versus function. - User (customer) value versus market segment.	- Value analysis in conjunction with the user (tenant) and the marketing department at the facility supplier for defining which functions should be included in the "facility product" considering the consequences in the form of costs. - User (tenant) value versus market segment, corresponding to different hospital departments having different budgets to spend on the "facility product".

Figure 2 . Specification of general design criteria appropriate for both the industry and the healthcare sector. These criteria have been applied to healthcare building facilities in Sweden, e.g. the hospital in Karlstad.

6 CONCLUSIONS AND FINAL COMMENT

This paper has specifically discussed the building design process in general, using the terms the "industrial product" and the "facility product" (see figure 1). By taking advantage of general design criteria, it proved possible to crystallise some characteristics of the "facility product" of the future, as applied to the healthcare sector (see figure 2).

Figure 2 explains the internal communication and relationships (codified I in the figure) in combination with the external communication and relationships with the organisation surrounding the product (codified II in the figure). An organisation which provides products and/or services to various users (customers) is based on a product design process that is a result of a more or less formalised process (codified III in the figure). The application of these design criteria results in a more efficient product (codified IX in the figure).

As is evident in figure 2, the industrial frames of references should be transferable to the "facility product". This transfer must, however, recognise that the time perspective of the building trade is shorter than within industry. The building design process (comprising the planning, building and maintenance phases) is a matter of some years. After this time, some of the traditional building design representatives (building design participators), such as designers, main and subcontractors, leave the property owner, property managers and user (tenant) with the completed building, in order to initiate yet another building design process elsewhere.

There are, in fact, new forms of legal contracts under discussion for building facilities that are rented by professional users (tenants). These forms are chiselling out various functional aspects, like responsibilities for various building systems and maintenance aspects. Another consideration aimed at the professional user (tenant) is to establish long-term contracts. This sometimes includes a deposition sum for specific services and functions during e.g. a ten-year period.

Example:

- In large Swedish hospitals, built in the 60s and onwards, the development of expensive technical equipment, combined with a general belief in the economic advantages of "large-scale production", caused a concentration of resources for diagnostics, treatment, and service of centralised buildings. This concept relied on proximity and straightforward communication between various departments within the hospital. Large, connected, structures of an unimaginable scale arose within the healthcare sector, where the patients were moved around like "goods by a distribution firm".

A result of this development was master plans for hospitals that distinguish between different zones, such as; "in-patient ward" for patients staying for more than one day, "out-patient ward" and "treatment facilities". All of these zones called for defined concentrated locations of their own in the building. Therefore, separate buildings were designed with a high degree of internal flexibility. Thus, hospitals were, as a whole, given an inherited static design that was not amenable to various types of reformations. This fact is evident for many existing hospitals today (see figure 3).

Nevertheless, new concepts for organising medical services are successively being developed that exploit the potentials of highly specialised medical services. At the same time, a number of more autonomous and more complete small-scale organisations focused on medical specialities like cardiology, neurology and orthopaedics are being concentrated in various types of centres (Wiklund, 1996 and 2001).

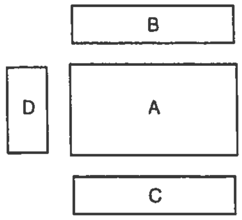
The internationally proclaimed idea of "patient-focused care" is another type of concept, which gives rise to new user (tenant) demands on the building facility. Briefly explained, this concept implies that doctors, nurses, equipment and other types of resources will come to the patients wherever they are. In the most extreme case, this means that the resources are brought to the patient. This is in contrast to the "large-scale production" of the 60s. It is, however, also possible to identify a generic healthcare building facility, which is composed of a mixture of the large- and small-scale concepts, as is the case in, for example, the hospital in the Swedish town of Falun (see figure 3).

To summarise, the master plan for the hospital of the future will successively be reformed into organ-based centres that have a building of their own, along the line of a campus area. The patients would only be moved around in the hospital in exceptional cases, when there is a need for highly specialised diagnostic equipment or treatment. The university hospital in Trondheim, Norway, which is under design, is an actual example.

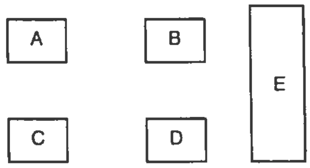
In the specific buildings for such a centre, there are beds and equipment as well as possibilities for diagnostics, treatment and rehabilitation. The building also acts as a centre for follow-up care in direct contact with the patient on an out-patient basis combined with facilities for out-patient treatment and home care. It is also a centre for close co-operation with the patient's own local care centre and family doctor, as some urban districts are sometimes situated in another urban district.

An individual building located in an organ-based centre can gain an identity of its own by means of e.g. own entrances, which are easy to find for the patients, while its smaller scale also makes it more comprehensible to the patient. With the aid of telemedicine, digitalised radiology etc, various medical specialists are able to co-operate with doctors in smaller hospitals, local care centres etc that are located far away.

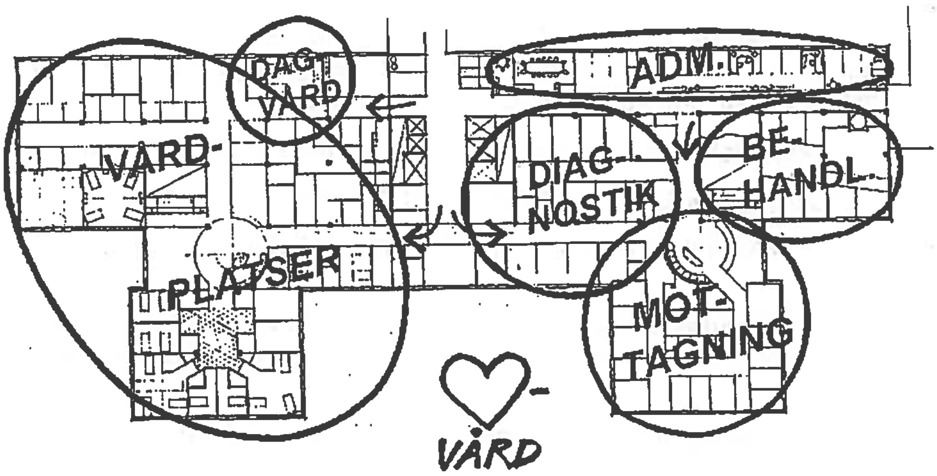
The hospital of the future will thus not just be a hospital as we recognise it today - it will be a hub in a de-centralised network serving patients not only in the hospital but also in local hospitals and, to a much greater extent than at present, in their homes.



The "zone-plan hospital".



The "campus-plan hospital".



A hospital which is a mixture of the large- and small-scale concepts.

Figure 3. Two different concepts of hospital design (top) and healthcare building facility, which is composed of a mixture of the large- and small-scale concepts (bottom).

The example above illustrates the two different concepts of building facilities for the healthcare sector, concepts that in turn might be interpreted to reflect e.g. assembly system design in industry. The "zone-plan hospital" is a reflection of an industrial process promoting movements of the product inside the building, i.e. the assembly line requires large-scale building facilities. The "campus-plan hospital" mirrors a more up-to-date parallel product flow assembly system, comprising small, autonomous work groups completing the vehicles being manufactured. In the latter case, it is not the products' movements in the building that govern what really happens, but the intra-work group pattern of the operators, as they are the ones who contribute their services to the product. By analogy, the different medical professionals are concentrated around one patient. To conclude, it is the authors´ opinion that there is a great deal to learn from interaction between the two branches dealt with in this paper.

REFERENCES:

Andreasen M, Hein L (1987). "Integrated Product Development". Bedford IFS Berlin, Springer Verlag, New York.

Bergqvist L-G, Rönn M (1997). "Att flytta – Rum för nya tankar". Chalmers Tekniska Högskola och Ortopediska Kliniken, Regionsjukhuset i Örebro (in Swedish).

Engström T, Bergquist L-G, Gasslander J-E, Örtengren R (2000). "Brukarmedverkan vid planering, bygg och förvaltningsprocesser inom högskoleväsendet – Några erfarenheter, paralleller och reflektioner". Arbete människa miljö & Nordisk ergonomi, (in press and in Swedish).

Engström T, Bergqvist L-G, Gasslander J-G (2001). "Linkage of User (Tenant) Demands to the (Physical) Building Facility – Reflections on experiences and methods from the automotive industry and its implications on the "hospital of the future". I:st international conference on The Hospital of the Future (in press).

Engström T, Jonsson D, Medbo L (2000). "The Method of Successive Assembly System Design: Six case studies within the Swedish automotive industry". Agile Manufacturing: 21:thCentury Manufacturing Strategy, Gunarsekaran A. (ed.), Elsevier Science Publishers (in press).

Eriksson K (1987). "Vårdandets ide". Almqvist & Wiksell, Stockholm (in Swedish).

Eriksson K (1988). "Vårdprocessen". Norstedts Förlag, Stockholm (in Swedish).

Graf W (1965). "Köfri sjukvård en framtidsvision?", Närkes Allehanda, 12 Juni, (newspaper article in Swedish).

Granath J Å (1991). "Architecture, Technology and Human Factors – Design in a socio-technical context". Industrial Architecture and Planning, Chalmers University of Technology, Göteborg (Ph.D. thesis).

Grönroos C (1997). "Relationship Marketing: Interaction dialoge and value". Svenska Handelshögskolan, Helsingfors.

Gustafsson R-Å, Carlsson A, Henriksson J (1991). "Kan vården demokratiseras". Arbetslivscentrum, Stockholm (in Swedish).

Henriksson J, Gardell B, Mächs A (1983). "Eckeröprojektet 1982 – 1991". Jan Henriksson Arkitektkontor AB, Stockholm (in Swedish).

Holmberg G (1995). "Effektivare operationsplanering". SPRI-rapport 396, Stockholm.

Lundholm A-M (1996). "Kris hotar Naturhistoriska Riksmuseet. 40 medarbetare kan få sluta. Regeringen kompenserar inte inflationen. Hyran tar halva anslaget". Svenska Daglandet, 11 juni, p. 15 (newspaper article in Swedish).

Medbo L (1999). "Materials Supply and Product Descriptions for Assembly System – Design and Operation". Department of Transportation and Logistics, Chalmers University of Technology, Gothenburg (Ph.D. thesis).

Olsson F (1976). "Systematisk konstruktion". Institutionen för Maskinkonstruktion, Lunds Tekniska Högskola (Ph.D. thesis in Swedish).

Oresten B, Löfvenberg K (1998). "Rätt beslut. Investeringsbeslut i offentliga organisationer". Svenska Kommunförbundet, Stockholm.

Pettersson K (1964). "Framtidens sjukhus. Har människan mer i centrum". Expressen, 21 Februari, p. 14 (newspaper article in Swedish).

Pugh S (1990). "Total Design: Integrated Methods for Successful Product Engineering". Addison Wesley.

SOU (2000). "Sammanfattning och förslag". Särtryck av Byggkostnadsdelegationens Slutbetänkande", Byggkostnadsdelegationen, SOU 2000:44, Stockholm (in Swedish).

Steen J, Ullmark P (1982). "En egen väg – Att göra fackliga arbetsmiljöprogram", Kungliga Tekniska Högskolan, Stockholm (doktorsavhandling).

Svenska Kommunförbundet (1998). "Facility Management i sammandrag. Offentlig fastighetsföretagande i ett nytt perspektiv". Svenska Komunförbundet, Stockholm (in Swedish).

Ulrich K T, Eppinger S D (2000). "Product Design and Development". Irwin McGraw Hill, New York.

Warsen L (1996). "Planering av låggolvsbussar, pendeltåg T-banetåg". Transportforskningskommissionen (TFK), TFK-rapport 1996:2 (in Swedish).

Wicklund Å (1996). "Hospitals in the 21st Century". European Hospital Magazine.

Wikforss Ö, Lundequist J (1996). "Planerings-, bygg- och förvaltningsprocessen. Byggforskningsrådets program- och uppföljningsgrupp för planerings-, bygg- och förvaltningsprocessen". Byggforskningsrådet, G18:1996 (in Swedish).

Wiklund Å (2001). "Vårdens och vårdens byggnader i ständig förändring". Arkitekturforskning, Stockholm (in press, en Swedish).