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From Manufacturing Green Office Furniture to providing Sustainable Workplace Services: A necessary change in practices, tools and approaches

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Abstract

A world leader company in office furniture like Steelcase is moving its business from manufacturing physical products toward more integrated solutions for work environment. Through this new strategy, this company aims to develop a new business which makes possible to satisfy the various needs of customer and workspace users, to anticipate the future tendencies, organisational and cultural changes in work and to be in compliance with sustainability recommendations. The objective of this paper is to feature Steelcase Company within its actual competing situation, to characterize from a design point of view, its know-how, its processes and tools. After this statement, we stress the issues raised by the shift from a current state of green product offer to sustainable integrated solutions of workplace. One of the main challenges is to monitor the emerging performances of the design alternatives - technical, economical, environmental and social - during the design process and to be able to comment a few variant solutions in a multicriteria way to the clients. The suggested solution is to adopt a modelling and capitalization approach for the performance measurement of workplace solutions.

Keywords

Sustainability, integrated solutions, workplace performances, eco-indicators, social performance, performance aggregation

1 INTRODUCTION

The competitiveness of the office furniture industry is strongly affected by the globalization of trade exchanges. It is heavily subjected to the competition of the low cost labour countries which are able to offer products much less expensive to the Western customers. Like other industrial sectors, one of the keys for this industry is to count on the creation of differentiated offers to their prospective customers. Parallel to these market trends, the concept of sustainable development resulting from the Brundtland report [5] is more and more a reality in companies under the pressure of authorities and market demand. This concretization appears in particular on the environmental side by actions of certification of the sites (for example by the implementation of certification ISO 14001 of production sites and registered offices in France or EMAS in the United States and Northern Europe). Generally these steps are well developed on plants where environmental work is carried out to reduce waste flows and environmental impacts of processes. However, these actions rarely exist for administrative and tertiary buildings. This is why additional actions must then be planned for this kind of space in order to improve the organization performance and the work functioning within the framework of sustainable development - social, economic and environmental -. Therefore, this new need constitutes a real opportunity for industries of the office furniture to create a new business and to propose a new offer. This new offer should not be based any more on the sole sale of material artefacts (offices, chairs, storage...) but on systems incorporating these artefacts, their places and use terms in order to propose optimized solutions during the lifespan of these systems according to the three dimensions of sustainable development (economical, environmental and social).

In this paper, we are interested in the particular case of the Steelcase company whose previous actions in

ecodesign of products and in adjustment of workplaces gives it a significant lead against its competitors. It's an exemplary case of an American company established in Europe which is a world leader in its domain of office furniture. We endeavour to index the difficulties with which it is confronted to shift from the supply of products to the provision of integrated solution in the form of a tertiary workspace. Beyond, we describe some tracks of change to reach that point and to ensure performance of workplace.

First, we present Steelcase Company and its know-how in workplace design, and then we describe the difficulties and complexities related to the shift from product manufacturing to service providing. Finally we present our approach for the evaluation of workplace performance complying with sustainability issues and technical requirements.

2 ECONOMIC REALITY AND COMPANY STRATEGY

2.1 Economic and competitive situation of Steelcase

Steelcase is the world leader of the Office furniture; it is also the world leader in the design and the adjustment of workplace solutions. It has more than 500 product lines which are sold through a network of more than 800 dealers in the world. Its products are manufactured in more than 35 factories. Created in Michigan in USA in 1912 as a manufacturing company of metal office furniture, it has become today a company which also proposes services of consulting in organization and planning of workplaces. It has more than 80,000 client companies during the five last years with a sales turnover of 2,6 billion \$ in 2004. The European market of office furniture presents a total sales turnover of 7,8 billions euros in 2002, which recorded a fall of 19,9% compared to 2001 (9,7 billions of euros). This fall of the sales turnover is explained by the decline of the investments in office furniture by companies resulting from the hard

economic situation these last years in particular in the ICT sector. This market situation generated a fall of sales turnover from 6 to 2,6 Billion \$. Contrarily to the American market where 5 leader companies represent more than 80%, the European market is very fragmented since the 10 leaders of the European market represent 30% of the total sales turnover [3]. However, Steelcase has gained market shares these last years through its innovations on products and by the diversification of its offer through services of organization and planning of workplace. Its new user's oriented strategy gave it a good reputation on the market. However, it is currently noticed that the market is characterized by an increasing number of companies and consulting agencies in Europe providing services of organization and adjustment of workspace. Thus, the Steelcase new orientation towards integrated solutions of workspace adjustment is in particular a result of the strong competition on product by the Asian countries (Exp.China) and by the emergence of new customer needs for customized solutions for their workplaces. This situation was a lever of action for Steelcase to reconsider its strategy and thus to acquire new knowledge that enables it to be repositioned on the market.

2.2 Steelcase Strategy toward innovation and sustainable development

The Steelcase Company has an historical know-how in the manufacture of office furniture. In 1974, Steelcase carried out a Joint-venture with the company "Strafor" the French leader of manufacture of the office furniture. Later, it acquires 100% of the capital of Strafor in 1999. Steelcase received its first patent in 1914 for a steel wastebasket -- a major innovation at a time when straw wastebaskets were a major office fire hazard. Steelcase deposited more than 1400 patents until today. Today, Steelcase portfolio of solutions addresses the three core elements of an office environment: interior architecture, furniture and technology. Steelcase is a company strongly research oriented, it approximately invests 46 million \$ in R&D per year (6 million for fundamental research and 40 million for the industrial research in product development). Its research programs are developed in collaboration with universities like "Stanford", the "Royal College of Arts" of London, the Technical University of Vienna, or with companies like IBM, Canon. Steelcase promotes two values of innovation and sustainable development at a strategic level as well as by in-depth commitment of the leadership.

Concerning sustainable development, Steelcase initiatives are oriented towards three levels:

- The product of office furniture,
- The individuals who uses the workspace,
- The whole space layout at the micro level (space application) and macro (workplace).

Conscious that the office furniture product has a strong environmental impact, Steelcase developed an Ecodesign strategy for its office furniture products. This strategy made possible interesting results in the reduction of environmental impacts and the optimization of Life Cycle Cost. It developed green product lines (exp: "THINK" seating). The environmental performance of this product shows the Steelcase expertise level in Ecodesign. Steelcase is also the first office furniture manufacturer to publish an environmental product declaration (EPD).

The contribution of Steelcase to sustainable development is not limited to the certification of its manufacturing units (ISO14001) which is now the case for most of European and even world Steelcase sites. It is a question of creating

products which integrate, in addition to the usual criteria of quality, of reliability and price, the preservation of the environment and the health of individuals. The environmental responsibility for Steelcase is reflected on its know-how on design of the innovative products with low environmental impact. That means to measure and analyze the environmental impacts of products at each lifecycle stage. Steelcase is the first manufacturer of office furniture to apply the expertise of Life Cycle Analysis (LCA) in the design of new products. The Life Cycle Analysis and the Environmental Declarations of Products (EPD) are carried out by Steelcase in collaboration with research laboratories (the Danish Institute of the Development Produced IPU¹, the Austrian Institute of Engineering and of Design TUW²). The result of LCA is then checked by means of a critical re-examination on behalf of French research institute (ENSAM). Steelcase also collaborates with "Mc Donough Braungart Design Chemistry" institute (MBDC³) for materials analysis. The matters are analyzed in accordance with a rigorous controls protocol, only the products considered respectful of the environment are used. All these collaborations with research institutions make Steelcase the leader in research oriented Ecodesign of office furniture, which confers to it a know-how in the management of multi-trades design projects.

Today, Steelcase wants to do more by an orientation towards the total performance of workplace, which is considerably impacted by the building performance. In the USA, the building makes part of the business strategy of Steelcase; it has a subsidiary company of construction "Workstage" which deploys an environmental strategy in this direction according to the recommendations of the American system of certification LEED ("Leadership in Energy and Environmental Design") of the "USGBC" (US Green Building Council). LEED [13] is a certification system which has been developed by the USGBC as a way to create a common way of describing and measuring what a "green building" is. In the LEED system, there are three LEED standards; one is LEED NC for new construction, LEED EB for existing buildings, and lastly LEED CI for commercial interiors. In the LEED standards, there is a common framework involving 5 elements: site selection, water conservation, materials & resources, indoor environmental quality, energy, and lastly opportunities for innovation.

In Europe, and in particular in France, initiatives go in this direction in particular through the system of certification HQE (High Environmental Quality). This certification HQE is a voluntary step, it offers a common language (14 targets), precisely describing the environmental characteristics of building. Today the building is in the heart of sustainable development concerns. Initially for the economy, the sector weights more than the 1/5 of the GDP (Gross Domestic Product) in France, associated to water and energy consumption and services necessary for building functioning. With regards to environment, Building effects are considerable, through high resources consumption, impact in natural environment and landscape, discharges of used water, waste and air pollution, waste production in building site is equivalent in quantity to domestic waste (in France). The building also interferes on the comfort and the health of the users: people spend 90% of their time in a closed universe.

¹ www.ipu.dk

² <http://tuwis.tuwien.ac.at/>

³ <http://www.mbd.com/>

Research starts today to establish the link between certain respiratory diseases and the air quality inside constructions [10].

In France, there is a growing interest to apply HQE targets in the construction and the rehabilitation of building. But, from an economic point of view, the application of some target is not strategically profitable because of the long duration of the return on investment on certain installations. On the other hand, in the USA, there is an increasing demand of the LEED certification by the customers. Steelcase has the first factory certified LEED in the USA causing considerable savings on energy and water consumption.

Another important aspect is the office interior design that plays a great role on economic and social dimensions of the company. It has been noted that a better comfort in work may significantly increase the productivity of the employees and improve organization efficiency. But currently, these improvements are not well evaluated; the only evaluation which is made is about organization efficiency after the change and the only sustainable Development performance evaluation is concerning the environmental impact of physical product.

2.3 New strategy toward service oriented solutions and sustainability performance control

Today, an increasing number of industrial companies are developing new market opportunities through an orientation toward more sustainable business models that help them in the same time to comply with environmental pressures and sustainability recommendations. This is the case of the office furniture sector characterized by important raw material consumption (wood, plastics, steel...) and large quantities of waste. This requires re-examining the behaviour of the product in order to reach a more effective use of office furniture products. Consequently, this evolution is concretized in some companies in the sector by the development of integrated solutions satisfying the need of organization and work process. These integrated solutions consist on the adjustment of workspaces which consider all the requirements for creating a performing work environment for a company (space planning, specification of furniture, lighting, acoustics, wiring...). In the literature, some authors make the comparison with Product-Service systems concept [14; 16]. This concept aims to promote sustainable business models in market, but the problem is that consumers are waiting to be convinced by the sustainability performances of this type of consumption modes and expected added value.

In this direction, Steelcase developed its Workplace Services on the basis of knowledge and skills that Steelcase has gained through the contract furniture industry and through extensive workplace research. Steelcase offers a portfolio of services that helps people to work more effectively, organizations to use space more efficiently and therefore improve individual and organizational productivities.

The expansion of workplace integrated solutions is particularly true in the USA where the demand is increasing from companies and that begins to extend more in Europe. An increasing demand for these services are more and more observed when companies want to invest in new effective and sustainable work structures. The Facility managers are increasingly conscious that the workspace is a resource that they can make profitable and present a performance lever for the organization.

In addition, with the current competition state, Steelcase is forced to develop its offer to survive on the market. Its

specific know-how in workplace services presents a competitive advantage from other office furniture manufacturers, in particular the Asian competitors. This know-how is based in multidisciplinary research orientation (sociology of work, ergonomics, etc...) and considers the different work cultures in local markets.

The question asked today is how to demonstrate that providing integrated solutions for workplace (a composite of physical products and immaterial services) is more respectful for the environment and economically profitable for the customer and services suppliers?

In literature, the concept of Product Service System (PSS) widely introduced as a new Business model which makes possible to decouple the economic growth from the environmental degradation [8; 15]. Other authors[3] discuss the fact to develop new strategies for office furniture sector based on the same principle can give the opportunity to close the materials life cycle and optimize resources consumption. However, integrated solutions for workspace increase complexity of system and therefore put the accent on the problems related to performance management at least of an environmental and social point of view. Another result consists on how to convince the customers that financial saving is possible through an alternative solutions and the return on investment related to a given solution.

In the third part of this paper, we describe some Steelcase business process and we try to identify the main requirements to concretize this strategic orientation and the difficulties to overcome in order to well control the expected performance AMBIGU for customer.

3 STEELCASE KNOWLEDGE IN WORKPLACE SERVICES

3.1 The Design Process

The design process of Steelcase workplace solutions (Fig.1) is approximately equivalent to the traditional architectural programming process but improved by know how acquired by Steelcase through its research initiatives around the "Community based Planning" field. A great part of the design process is based on the exploration and analysis of organization (audit of departments, observation, and work modes analysis) and the comprehension of management and users needs.



Figure 1: Steelcase Workplace Design Process

This design process is the result of the improvement of the traditional architectural programming process by the community based planning research findings. The design process follow an approach that aims to identify design principles and attributes following the desired behaviour and performance of workplace that consider organisational flexibility, social networks and evolution business process and work styles (See Fig. 2).

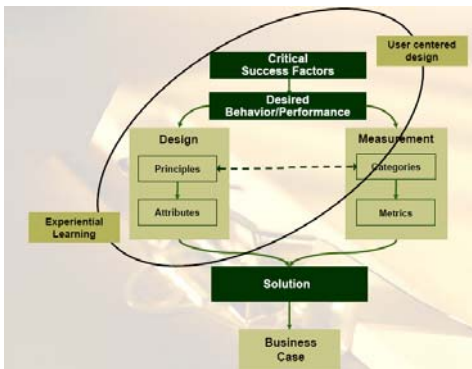


Figure 2: Steelcase Design Approach

Thereafter, the results is linked to client business drivers and materialized by Planning Principles between six generic (Tab. 1). The late are 6 aspects of the work environment that should be considered to leverage modular architecture, furniture and technology and create a fully integrated high performance work environment. This is a way to link the workplace and their workers' abilities to be highly effective within their work environment.

Planning Principles
1) Balance privacy
2) Manage connections
3) Make work visible
4) Support diverse workstyles
5) Manage facilities strategically
6) Offer inspiring spaces

Table 3: Steelcase planning principles

In the next section, we show that the design process is strongly linked to the organization performance analysis and based on a user centred approach.

3.2 Analysis of organizational performances

Steelcase launched a new approach for workplace design for its salesmen, interior designers and client whose marketing name is "Inspiration Office". This approach consists of a new vision of workplace and develops a new methodology of design and workplace evaluation based on a new school of thought called "Activity Based planning". This methodology has been enriched by a user centred research that Steelcase has led for several years and which has allowed improving its tools. Steelcase has studied the results of several of its research projects by integrating models of "Community-based Planning" which aim at including/understanding the social relations which govern the work environment and "User Behaviour Patterns" which relates to the behaviours of workspace users. The results of this research consider the following aspects:

- The new tendencies affecting organization in 3 principal fields: processes, technology and individuals.
- Space is a strategic resource which has a strong impact on the results of the business process.
- Users oriented approach: work is not simply a process but it is a social activity. The idea is to put the users at the center of the planning of the workplace in considering the important collaboration schemes between individuals and groups.
- The six planning principles previously evoked (see Table 1).

- 5 applications identified that summarize the required spaces for the daily activities which individuals carry out only or in group (see figure 3).

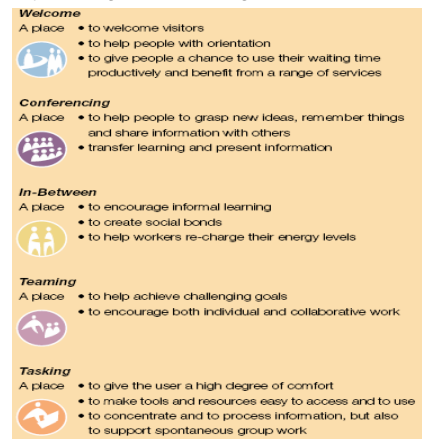


Figure 3: Steelcase space applications

- Five fundamental objectives for modern organization (business dynamics or drivers) for professional performance that a tertiary space must support and improve: communication - work process – Learning-Innovation - Decision-making

The Steelcase approach consists on identifying business drivers of the company, the formal and informal social networks, the critical success factors, and desired behaviours & performance by uncovering the existing work environment, and therefore linking them with its Planning Principles.

The architectural design is the result of the above study. Office furniture and the required facilities and equipments for work environment are considered following the weight accorded to each planning principles, e.g.: if a company needs more confidentiality or privacy, acoustic technologies will play an important role.

4 TOWARD CONTROLLING GLOBAL AND LIFECYCLE PERFORMANCES OF WORKPLACE

4.1 Performance control requirements

There are actually two distinct needs (for customers and space designers) to better control the total performance of workplace:

- For the evaluation of concept performance current design by the designers/architects. An evaluation "on-the-fly" brings a constant decision-making aid to build a good solution. In the same manner, a multi criteria choice is then possible between radically different solutions. This multi criteria choice can lead to a selection of a sub-list of "viable" concepts (in mathematical terms, Pareto optimal solutions with no clear domination of a solution over another for all criteria).
- Like a multi criteria reporting tool for the few viable concepts suggested to customer. This customer will be then able to make a decision by knowing the level and contribution to performances of each solution. He /she will be able to make a compromise in accordance with his/her strategy (for example: a higher initial investment but lower cost of exploitation/maintenance and better social and environmental performances).

For resulting in this "real time" or "upstream" evaluation, it is necessary to precise what kind of virtual simulation of workplace performances along its life cycle one should

implement. This requires finding solutions to three issues exposed through three following sections.

4.2 Clarifying local performance of workplace components

In workplace adjustment, a lot of components take place to make the space functional (see figure 4). Needs for lighting, acoustic control, connectivity, air HVAC, space partitioning, technological equipments and office furniture adapted to various working modes, should be specified according to the architectural programming of space and building requirements. In the case of Steelcase workplace solutions, these local performances can be estimated separately or by applications (Tasking, Teaming...).

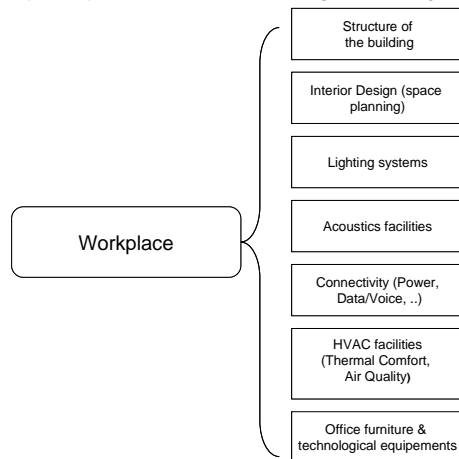


Figure 4: Workplace components

The multitude of artefacts involved in the interior design of a workplace makes the constant updating of global performances very hard to perform.

This basically requires a capitalization of local performances at the component level and an identification of the contribution of each one to the expected performances. For example, the investment/exploitation cost, the equivalent initial/exploitation CO₂... It is necessary that this capitalization of performances lead to predictive models depending of the variability of the components' attributes. One would like to result in parametric models of performance. The construction of these models can be made in various manners: starting from previous data that one statistically analyzes (principal components analysis [20], classification methods), that one compiles considering a set of previous design cases (artificial neural networks, case-based reasoning [12]), that one builds from experts' knowledge (parametric models built a priori, model of fuzzy rules known as of "subjective evaluation"), or by a combination of both (neuro-fuzzy models). See [6] for the three last categories.

4.3 Modelling lifecycle, flows and interactions

To estimate and/or simulate the environmental and social performances, or even estimate other technical performances like the average level of maintenance for an installation, it requires a thorough modeling of the components of service, material/energy/financial flows and transactions between significant actors throughout the system life cycle (e.g.: "it is probable with a given probability that at the end of a period while having chosen this fitted carpet, one needs a replacement which would require a deceleration of activities equivalent to 1 day lost for the company at a given cost").

It is necessary to be able to consider the local performances, to set up a skeleton of an information system possible to deal with the relevant data. There is a

need for different sources of data necessary to calculate local performances (component features and performance, LCA and LCC data...). Thereafter, we can use other techniques to lead to total performance indicators meaningful for designers and customers. We may think about three solutions of tools to consolidate modeling and simulation around life cycle:

First, *Life Cycle Analysis (LCA)* software may be used in order to make an inventory of the environmental impacts on all the physical objects (artefacts) composing the workplace (the office furniture and other equipments) and to aggregate them into global indicators. It exists today on the market a lot of LCA software which permits to calculate the environmental impacts of products (SimaPro, EIME, GaBI...). This type of software enables to carry out inventories of input and output flows and to incorporate them according to categories of eco-indicators. The method Eco-indicator 99 [7] used by some software tools may be useful technique. The LCA software has the advantage to make a modeling (possibly qualitative, which is useful in the preliminary design) of material and energy flows and an estimation of the environmental performances. But, the major drawbacks stand in the lack of modelling of actors in connection with the service at a given time and, secondly, they don't consider the social, technical or financial performances. In addition, LCA tools are not really adapted to the modeling of immaterial parts around the service and they are not opened at the point to customize performance parametric models for the physical components of a functional space (i.e. spaces Tasking, Teaming...). The LCA method requires financial and human means to gather the necessary data characterizing the lifecycle of service. The stake is thus to find a means for simplifying the complexity of this tool in order to support its use to develop sustainable service. One solution can be the study of modeling methods traditionally used in service design and to retain the one which can support the requirements and the global solution attributes of a workplace system/service.

Second, *PDM/PLM systems* [17] could theoretically be used to model data of artefacts and physical installations of a tertiary space through its lifecycle. But they are few adapted to the immaterial parts around service. The models of evaluation/simulation of performances must also be integrated, especially for environmental performances.

Third, the *Blueprinting model* is a modelling tool which documents the processes necessary to provide a service. The generated model enables to visualize the chronology of actions necessary to deliver the service and different interactions between actors.

The development of a Blueprinting model is an interesting means for modeling workplace service. The "Blueprinting" is a method invented by Shostack [18] and developed by Kingman-Brundage [11] to visualize a service. This model is widely described in literature as a modeling tool that offers a global vision of the activities and flows of a service and which is convenient for aiding in the design process of a new service as well as the redesign of an existing service. It adopts a 2D representation in the form of chart representing four levels of the company service (from the most inner layer to the most outer layer) along the time line. The physical actors, artefacts, flows and transactions are then modelled in space and time. The advantage of this method of service modeling is that it is well adapted to life cycle modeling of services. The roles of each element necessary for providing service appear: products, equipment, technology and employees. The

Blueprinting model permits to simplify the complexity of a service by dissociating all its elements. This representation in elements and interactions reveals the material aspects (infrastructure, products, building...) as well as the immaterial ones (decisions, networks...) of the complete system. The blueprinting models serves as a skeleton of an information system which logically structures the data about activities in term of cost, flow, quality but also of environmental impacts. It may support the actor's actions allowing to well apprehending their roles and responsibilities on the (physical) artefacts and relatively to a given service (immaterial transaction). Each element of the Blueprinting model may be informed with specific performance information (technical, social, environmental). It results in a data structure that can be analysed to attempt to consolidate or aggregate global performances for the whole workplace system/service. It could be used to identify some centers of "non performance" from cost, technical/quality and environmental elementary performances. Blueprinting can then be thought as a tool of decision-making aid which considers the resources allocation, the strategy of the company, the performances expected by the customer. The main issue to face is that the mechanisms of consolidation or aggregation of elementary performances and other data into more global performance simulations is a hard modelling problem.

At the stage, we made the choice to perform a Blueprinting model of a workplace solution (building, interior installation) from the establishment of its specifications until the end of life scenarios (take-back, recycling, remanufacturing...) [4]. Figure 4 displays a (small) part of such a model. Our experience was satisfactory in the sense that much of important data required for a global performance evaluation of the workplace system/service has been naturally introduced somewhere in the model.

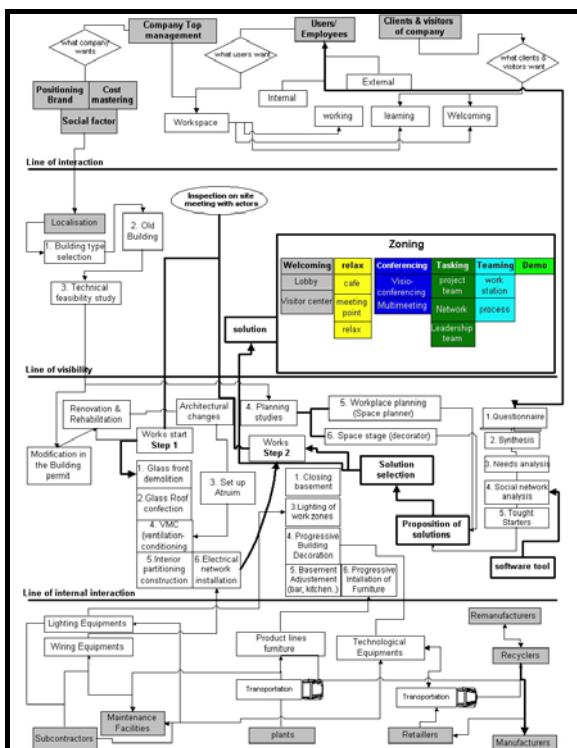


Figure 5: Blueprinting model of workplace service

4.4 Developing a sustainability aggregation logics for local performances

The next issue is to be able to compose local properties (performances) of physical and immaterial components

(assuming we benefit from local performance parametric models) into more global properties/performances of a workplace service:

- For the cost performances, the logic of aggregation is generally additive, possibly through typologies like realized/invested, investment/exploitation costs. Moreover, this additivity can also be simulated along the timeline of the workplace lifecycle, which can be very informative for a decision maker.
- For the environmental performance, we think at merging or incorporating indicators like those used in Eco-Indicator 99 approaches [7], as well as LEED's [13] and HQE's [10]. The logic of aggregation is rather additive because it is a question most of the time of capitalizing material and energy flows from the different components of the tertiary space. Certain scales can however be nonlinear: This is the case when some threshold effects occur. For instance, the overall safety factor level of a mechanical structure is the minimum value of the different safety factors' levels corresponding to the degree of respect of the different mechanical constraints [19]. Adequate aggregation operators must then be studied.
- For social performances and technical performances (type of maintenance...), the complexity increases. The performances of an overall system solution sometimes cannot simply be the summation of the performances of all the constituent subsystems (see [9] for the example of acoustical performances of a whole mechanical structure). Typically, the overall workplace technical performance is not only the sum of the intrinsic performances of the different constituent applications (welcoming, teaming...), but it widely depends on the relevance of the space planning. There is a value in the assembling of components, in the planning between sub-spaces or applications itself.

In addition to these system effects, it is necessary to know how to incorporate social performances like "comfort, well being of employees", etc. Must we take the average value or the worst case of the components' intrinsic properties? It is thus necessary to develop a formal mathematics for the aggregation of performances (see references on preference aggregation models [1; 2]).

5 CONCLUSIONS & PERSPECTIVES

Today, new tendencies in work environment strongly impact the office furniture sector. Most of manufacturers are oriented to develop strategies in accordance with these evolutions through integrated solutions for workplace. We focus in the case of Steelcase company which chose to enrich its knowledge on people at work and sustainable development. Its initiatives were initially oriented to the improvement of product quality, environmental performance of products, and providing customized solutions for customers. But today, Steelcase wants to control the total performance of its workplace integrated solutions in order to better match its customers' expectations. In this paper, we present a framework to develop logic for the total performance evaluation of a workplace according to three sustainability principles (economic, environmental and social) and considering the technical and organisational requirements. For building this logic, we have identified three fundamental modelling prerequisite consisting in a service modelling approach, a capitalization of local component performances and a performance aggregation process in order to consolidate global performance indicators. This performance

evaluation process will consider the whole workplace system (structure of building itself, products and equipments), while recording the different architectural programming stages and the requirements of the working organization and individuals. Our framework must be considered as a modelling approach through an information system, an approach of performance capitalization, a simulation system of global performances of a compound service which will be of great value for designers during the design process as well as for

establishing multicriteria reports on different design alternatives proposed to the clients.

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