PROCESS MODELLING FOR PLANNING AND MANAGEMENT OF FACILITIES: A RE-ENGINEERING APPROACH

Process modelling of facilities

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Abstract

This research had two major objectives. The first was to determine and evaluate the factors required in facilities management and the effect of business type on them and the second was to develop and test a model for management of facilities based on the factors. Factor evaluation revealed that for 76% of the factors there were no differences between the respondents regardless of business affiliation. Where there were differences they hinged on business specific process dimensions. The results of the factor analysis and the basis of the factors used in the analysis enabled the conclusion that the resultant factors are important in facilities management.

A facility management model made up of process, need, service delivery and assessment sub models was created. The model represents the facilities management environment via three variables namely, real time needs, real time status of the facilities and service concept. In field tests, the model was found to be both effective and efficient at handling management information.

Keywords: Management, process modelling, re-engineering, serviceability, performance, and assessment

1 Background

There is increased complexity and dynamism in customer needs spurred by more awareness of rights caused in part by information technology. In response to this, more change responsive and effective paradigms are required to understand needs and deliver products or services. The manager of facilities must have a way of identifying and understanding needs and the relationship between processes and facilities.

Business opportunities and product development cycles of many high value products now have such short duration of even 2-3 years and the time to market often determines their economic viability and profit margin [LIFE RC, 1995]. Rapid delivery of facilities through retrofitting or new construction is an important competitive tool for such firms. Ensuring real time appropriateness of the facilities is just as important.

The Architecture, Engineering and Construction (AEC) industry with its ubiquitous nature is one of the largest industries. In Finland it accounted for a Gross National Product (GNP) of about 15% in 1997 [Tilastokeskus, 1998]. An improvement in the life cycle processes in the industry has a potential to result in cost reduction and benefit an economy as a whole.

1.1 Research problem and formulation

1.1.1 Problem analysis

Although facilities management has been recently identified as being an important corporate function [Stephens, 1994], the factors that should be used in the management process are not very clearly expressed in research. There are no models that deal effectively with information handling or categorisation and into physical tangibles and use factors, an approach that has been found to be useful in facilities planning phase. Evidence from the field indicates that existing models have very large views and are often ineffective at handling the usual chores of facilities management [Barret, 1995]. The effect of these problems is that facilities management is often carried out with unstructured or even partial information.

1.1.2 Formulation

The facilities management paradigm should be simple to apply but with clear responsibilities which include compliance with business requirements. The method should be effective at linking the systems and parts of the facilities to the needs. To achieve these requirements the facilities management model should have the following capabilities:

1. A means of analysing the processes of management to establish a functional design
2. A means of determining the required service levels or need levels to satisfy the requirements of business
3. A means of delivering service detailing the factors that are required to enable the delivery of the defined service
4. An assessment module for checking the effect of change in the facilities

This study had two main objectives. The first was to study the factors required in facilities management and the effect of business type on them and, (2) to develop and test a model for management of facilities based on the factors.

1.2 Theoretical framework

A management system was required in which the needs of the stakeholders are determined and balanced with the available resources. This system was determined by using the defining factors of objects. LIFE RC (1995) and Pena et al (1987) give the definition of engineering objects in terms of the following three factors:

1. Function - referring to design intent obtained from the client, code jurisdiction agency or common practice

2. Form - describing abstract geometrical or structural features of design including material specifications
3. Behaviour - referring to values of the form attributes like deflection energy use or project cost.

Supply and demand factors at the utilisation stage are governed by the same factors.

1.2.1 Research variables

Choice in a project is based on a working equilibrium involving the three variables. At feasibility stage the three factors represent possibility, desirability and managerial issues. At utilisation phase they are performance, serviceability and managerial or service concept. At a control phase like a costing stage the factors are tangibles' cost, user costs and managerial costs. This study uses the three variables as the basis for management and control for supply and demand factors in facilities. The dynamic nature of business means that established facilities set-ups only result in a moment in time satisfaction of needs. As time progresses, gaps may develop between supply and demand. Figure 1 illustrates the relationships among the three research variables with time. The real time status line represents the current or real time status of facilities. The line shows the facilities to be gradually deteriorating until they reach a failure point. This deterioration is due to ageing or other obsolescence factors. Needs of the stakeholders are represented by real time needs line. This line shows the usual fluctuations in the business environment. A horizontal line represents the current planned level of facilities or service concept. This service concept remains constant until it is changed. A new service concept may result in bigger or smaller facilities and is represented by horizontal lines above or below the original service concept as indicated by the dotted lines.

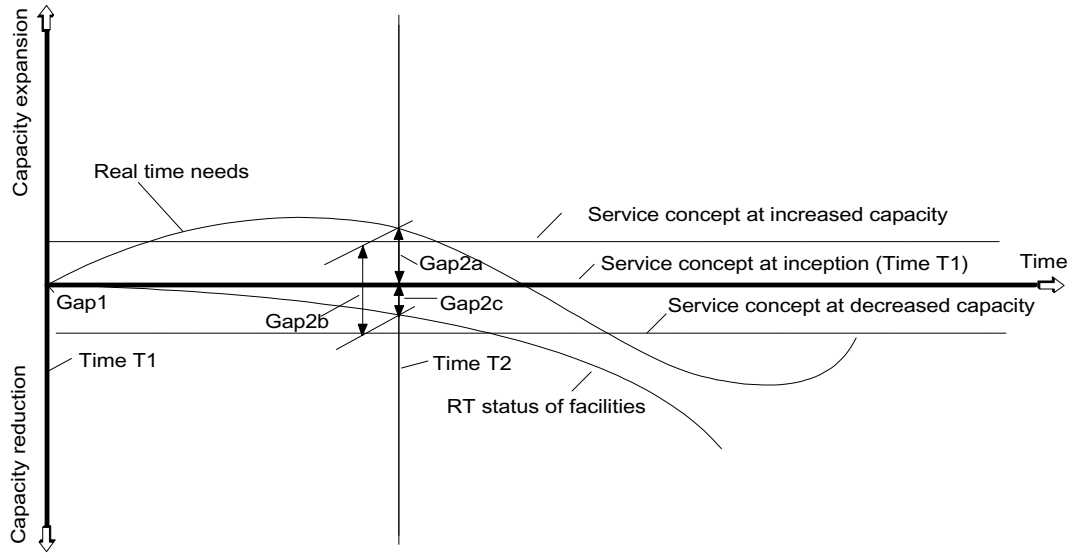

Fig. 1: Relationship among research variables with time

The lack of fit between supply and demand factors during the utilisation phase is represented by gaps between the values of the variables. T1 represents a moment in time when the facilities completely satisfy the needs and therefore there are no differences in value among the three variables. At time T2 there is a gap in the supply-demand relationship. The supply-demand mismatch is repre-

sented by three gaps. The gaps are analysed below.

1. Gap 2a between the **service concept** and the **real-time needs** indicates the extent of the relevance of the service concept or plans to the current needs
2. Gap 2b between the **service concept** and **the status** values indicates the extent of the compliance of the physical tangibles or performance factors to the plans or service concept.
3. Gap 2c between **real time needs** and the **facilities status** indicates the extent of the appropriateness of the physical tangibles to support the current needs

The gaps represent what the managers must do to ensure facilities' appropriateness. The solution can take the form of either changing the status or the service concept or both. Because the service concept is directly related to the business process, a change in it requires re-examination of business process. The modification of status factors on the other hand involves the improvement of the physical tangibles and services to restore them to the intended service levels.

2 The proposed facilities management model

The proposed model is composed of four sub models namely process, need, delivery and assessment models. The model is illustrated in Figure 2. The description of the components of the model is given below.

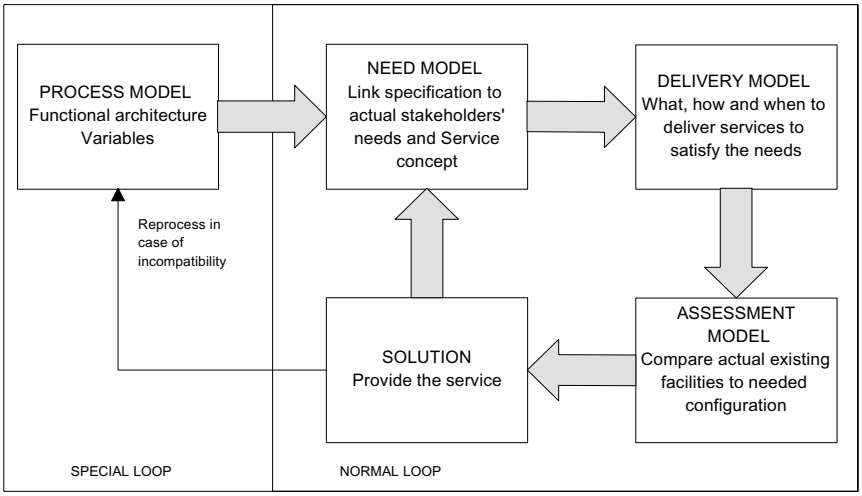

Fig. 2: The facilities management model

Sub-model 1: Process model. The process model is a functional architecture for defining facilities management activities and management information. The model was based on IDEFØ. The process model is not an everyday management model. It is useful in the case when complete reconstruction or major changes in the processes of business take place. Figure 3 shows the first level of the process model. Details of the process model can be found at reference (Ojwaka, 1995).

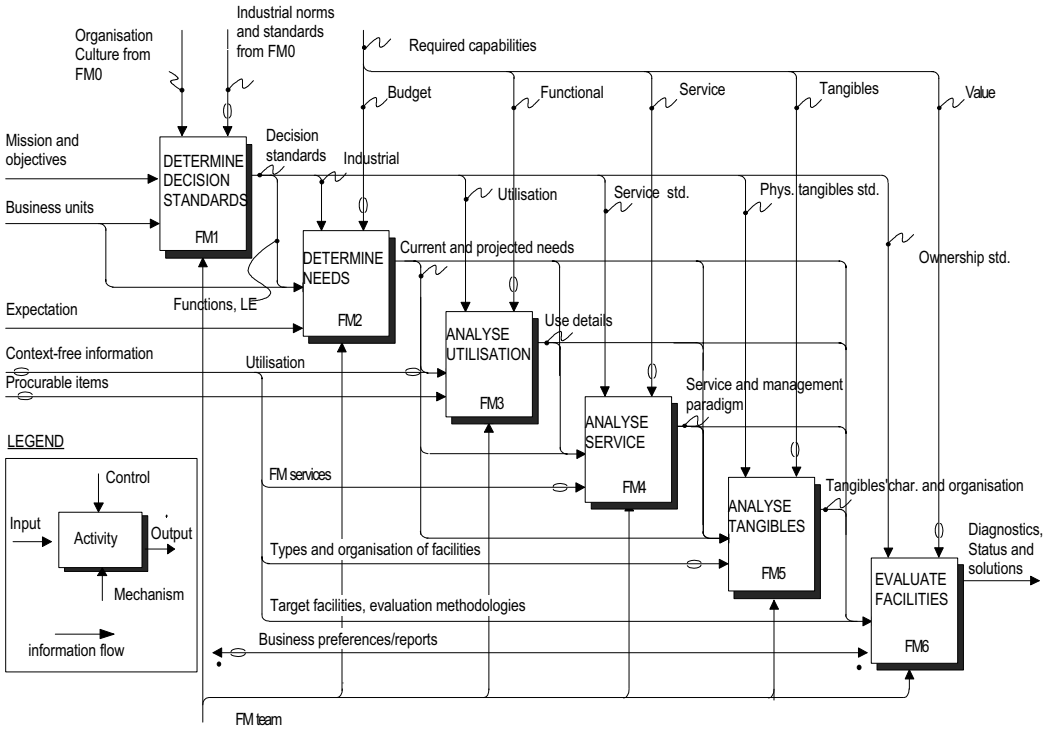

Fig. 3: Facilities management process model main level

Sub-model 2: Need model. The need model is a framework for determining the needs of the stakeholders based on process model. Need is an inventory of systems, parts and services necessary for the utilisation of facilities. Two types of needs are identified by the need model. They are the real time needs and business dictated requirements or the service concept (SC). Service concept is a level of service that has been adopted by the business. It is based on a snap shot of needs at a moment in time. Apart from needs of stakeholders, it is also based on funds in form of grants for running the facilities, process dictated requirement, management's own recommendations, importance and compromise levels for the objects and stakeholders needs. The value of the service concept is constant once it is defined and is only changed when a new plan is devised. Real time needs are the needs of the stakeholders during the course of the utilisation of the facilities.

To define the needs, the process model information is classified into objects, their functionality and occupancy or behaviour factors. The required system constraints like costs, time, capacity, quality, links etc. are used to establish the required elements of the objects, functions and occupancy factors. Typical first level need model analysis factors are shown in Table 1.

Table 1: Typical need definition factors

Constraint	Objects	Functionality (As designed)	Occupancy (As used)
Costs	Maintenance costs	Work design costs	Utilisation costs
Time	Support for required schedules	Support for functionality	Delay, Support for work design
Capacity	Physical size	Useable sizes	Work design sizes
Quality	Object performance quality	Serviceability quality	Serviceability quality
Links	Sys. links	Shared resources	Shared resources

Sub-model 3: Delivery model. The delivery model delivers the defined services on the basis of the need model to match needs and available resources. Every demand is compared with the supply prior to its implementation. The model defines the items and activities, which according to the process information are required to deliver the defined facilities management service and comply with the supply and demand issues.

Sub-model 4: Assessment model. The assessment model determines the needs of the stakeholders and compares them with both the status and the service concept. On the basis of the comparison, the model creates a report that details the gaps between supply and demand and also gives a recommendation on the course of action to rectify the situation.

3 Methodology

3.1 Factor determination

An initial factor list was created based on literature study of extant theories and practices to take care of utilisation, physical tangibles and the necessary standards and controls. These factors were partly derived from process management requirement which defines management functions as being primarily planning, improvement and control [Soares and Anderson, 1997; Juran, 1992; Shaw et al, 1988]. The initial factor categories are discussed below.

1. **Standards** examined strategically important issues for facilities management ranging from physical tangibles to utilisation and services
2. **Needs** examined requirements in terms of the usual problems in facilities, causes of these problems and solution selection criteria
3. **Utilisation** factors examined use dimensions like work design especially flexibility and other rates of use issues along with the effect of change
4. **Service** factors examined the functions that facilities management should carry out to ensure serviceability
5. **Physical tangible** factors investigated the business implementation environment for the relationship between facilities items and the processes of business
6. **Control** factors investigated issues of assessment for facilities including remedial actions and their impact on the facilities

Two instruments were used in the factor study: questionnaires and interviews. The value of the factors and their potential for use in everyday project and facilities management was sought. Four measures namely importance, expectation, rate of use and effect were used to judge the factors on a five-point scale.

The factor establishment exercise targeted those professionals involved in management of projects or facilities in organisations. The respondents were divided into two categories of profit making and non-profit making firms. The source for the profit making firms was the listing of the 500 top firms in Finland in 1995 from data on public firms. The source of information for the non-profit firms was a listing of public institutions including public colleges and institutions of higher learning, public hospitals and public libraries. Based on the population, a sample size of 10 percent was judged to be representative of the population under study [Campbell, 1987]. A total of 120 short listed firms were called and requested to participate in the study. Roughly 100 firms accepted the challenge and received the questionnaires. A total 72 filled questionnaires were returned on time.

3.2 Model testing

Model testing sought suitability and importance rating values for the three variables of facilities management. These values were then used to assess the facilities and hence determine the effectiveness of the facilities management model. The questionnaire was used obtain real time needs and the service concept on the scale of 1-5. Preiser (1972) showed that user response to a serviceability survey is a valid way of obtaining information on the serviceability of facilities. The real time status was obtained by condition surveys, questionnaires, measurements or by use of appropriate as built drawings. The relationship between the serviceability items and the performance items as expressed in the need model was used to identify those status items that needed to be assessed. A chart was developed for use in displaying the results together. The facilities were divided into building, space and service elements for the purposes of the assessment.

4 Analysis and results

4.1 Factor analysis

There were six original categories of factors and each with sub categories representing 231 factors. There was a strong indication that the vast majority of the respondents regarded the factors as being relevant for management. Both the median and standard deviation indicated this. For most of the factors the median was of the order 3 and above. To further investigate the factors the number of respondents finding the factors useful was determined based on responses of 3 and above. 54 factors were rated as being unimportant representing 23.4% of the total. T-tests analysis revealed that for 76.8% of the factors there were no significant differences between the respondents. An examination of the factors where there are differences revealed that the differences hinged on business specifics and how they influence management. On the basis of the factor analysis, a set of factors was elicited from the original factors. Principal component analysis generated a total of 99 factors to replace the old factors in the original questionnaire. In the factors analysis the relative importance of the factors can be seen in the fact that most of the original factors formed part of the new factors. The result of the analysis of the factors was a set of factors that were applicable to facilities managers.

4.2 Analysis of test facilities

Table 2 shows typical results for one of the facilities studied. It shows the average suitability and importance ratings for a building, space and services expressed in point form in a scale of 1-5. A low rating is an indication of unfulfilled needs. So a highly rated item compared to a lowly rated item simply means that the lowly rated item has a higher need for attention than the highly rated one. The comparison among the three items compares this demand. It is this demand that is a trigger for action.

Table 2: Average overall assessment results of typical facilities

Facility element	Real time needs		Service concept		Real time status		Overall diagnosis
	Suitability rating	Importance rating	Suitability rating	Importance rating	condition rating	Importance rating	
Building	3.2	3.6	3,5	3.2	4	3.3	Serviceability, functional and Communication problems
Space	2.9	3.8	3.4	3.4	3	3.6	Serviceability problems and deterioration of objects.
Service	3.7	3.9	3.9	3.9	-	4	Service concept does not support needs.

Assessment results indicate as shown in Table 2 that users were not very satisfied with the building. A rating of 3.2 implied that many aspects of needs remained unfulfilled. The average user satisfaction level for the building hides the fact that there were some four items that were rated below 3, a level below which the facilities need some attention immediately. The affected items were functional appropriateness of the building, parking space availability, building thermal comfort and air quality. The management of facilities had alluded to the parking problem during the data gathering time but the other serviceability problems were not apparent to them. It was interesting that the management still rated the parking space availability as being good (4). Management was also slightly more satisfied with the building than the users with a rating of 3.5 but has still relatively many unfulfilled needs. The service concept was not quite satisfied by the building. The status measure of 4 suggests that the physical tangibles and other performance items are generally satisfactory.

The result of the comparison of the three variables together indicated that for the building, plan and objects do not support serviceability – they are functionally inappropriate. There were also communication problems. In addition there was a slight service delivery problem. This refers to the case when business rates the facilities at a higher level than the users. It simply means that the service concept is not translated into satisfaction of the users needs. Because the status is rated at value 4 yet it does not translate into similar satisfaction rating for the users nor the business, this may mean that there is a higher demand on the status items. Than in the past.

Generally all the cases with ratings of near or below the value 3 should be targeted for remedial actions. This would depend on how easy it would be to repair the problems. In the building example shown in Table 2 all the items with the exception of circulation spaces in the building and parking space problems can be fixed easily. When any status items are repaired, there is no guarantee that the users will be satisfied. For a complete solution of the problem, the other two vari-

ables must be combined with the status results. The delivery problem can be addressed by making sure that what is planned is delivered. The problem of higher current demand is a problem that has ramifications for the plan or the service concept. It requires the service concept to be re-examined preferably via the process model in order to solve the problem effectively.

The field test indicated that method was easy and could be applied rapidly and at negligible costs. The field trials indicated that the model was able to determine quality issues for the facilities in more details than the facilities managers had been familiar with. By an importance rating, the managers valued the assessment items used in the facilities case studies as being of average importance rating of greater than 3. No differences were observed in difficulty of applying the model to facilities with operating management systems and those without. Results show that the analysis of one of the facilities confirmed management plans already underway of improving the facilities.

5 Discussion

5.1 Results

The **factor** evaluation had the objective of eliciting the factors that should form the basis for the management system. These factors were based on form, function and behaviour classification system. The question of what information should be used in facilities management is answered by these factors. Despite variations between firms, the factors used here are considered to be useful. The factors mirror factors used by other researchers like Baird et al (1990), Davis (1994), Lewontin et al (1990) and IFMA, 1993. Not withstanding business and national cultures, it can be said that good management practices remain universal and basically the same. It is this basic value that the factor analysis sought and determined. The sample size indicated that the results were a good representation of the population and hence the feelings of the facilities managers at the time of measurement. It is however conceded that results are influenced by the business expediency at the moment of measurement.

The **proposed management model** represent in general the functions of process management of planning, improvement and control as espoused by Juran (1992). The research model proposed that (a), the research variables are subject to different forces and hence change differently and (b), only a combination of the three variables provide the total picture required to ensure that both the serviceability and performance factors are taken care of in facilities management. The model assumed that when the three variables namely the real time needs, service concept and the status values converge at the same value then the item of facilities that they are referring to have an ideal supply demand relationship. From the results it can be seen that the three variables had different values as envisaged by the theoretical model. This bears out the fact that change, which has obviously occurred in the facilities, has caused differential effect on the variables. The theory proposed that only a combination of the three provided a correct assessment of the facilities. This can be seen in the fact that the values held by the variables seem to contradict each other. An isolated reference to one of the values value would obviously lead to erroneously interpretation of the situation in the facilities.

The FM model was proposed as the instrument for applying the theory. The effectiveness of the model is its ability to enable the addressing of the problem on

hand. The model proved to be an effective tool. It usefulness is partially displayed by the importance rating give by the stakeholders on the management variables and their importance to management. These rating are compatible with factor study results, which also largely found the factors to be important.

Management by fact is a key requirement of TQM. The facilities management model sought to provide the control handles that would enable the realisation of this requirement in facilities management. The model takes care of needs of the stakeholders regardless of their position in the importance hierarchy at the facilities. The needs of the stakeholders are compared to both the plans for the facilities and also the current status of the facilities. Specific parts of facilities serviceability or performance could be targeted. This fact solves a perennial problem of management pointed out by Barret (1995) that many existing models are very large and inappropriate for individual issues.

A management paradigm is as good as the quality of information that it uses. The information should be relevant and enable decision-making. The information used in the management of the facilities is derived form the firm's own process information. The findings from the case studies indicated that the facilities management Model is both effective and efficient at handling the information required in facilities management and provides relevant decision making information.

The research has relied on the existing scientific methods in its approach. The data collection, its analysis have relied on existing norms. Any differences are only due to the circumstance of the place of the research. The analysis method selected which comprised descriptive statistics for data classification, T test for determining differences between sample and hence populations' means and the principal component analysis for factor analysis are common methods. Both the methods have been used widely in research. A recent use of factor analysis was by Soares and Anderson (1997) and Ahmed and Kangari (1993). The results of the factor analysis and the basis of the factors used in the analysis enable the conclusion that the resultant factors are valuable in facilities management.

On the basis of the case studies it is clearly apparent that the theory has been tested and is applicable to facilities management. In addition the proposed model is a suitable vehicle for the application of theories.

5.2 Limitations

The scope of this study is limited to determination of factors of facilities management and the process of controlling them for decision-making purposes. It details how management information should be determined and handled in changing circumstances. The management of business functions housed by the facilities and their processes is not considered covered by this research. While the principle activities of facilities management are given as envisaged by the model, their management process is not covered.

A knowledge of what constitutes business needs in facilities, the end users needs and also the status of the facilities at the time of evaluation must be known in order for the management system to work. The later two are easy to obtain. Business needs requires more effort to obtain. It may place some limitation on some managers.

5.3 Theoretical and practical implications of the research and further work

The facilities management model is primarily aimed at objective setting, determination of needs, identification of problems and the organisation of information. It should therefore be useful in the definition of any product regardless of

the industry. In particular it should be very useful at identifying quality issues for the product involved. In such a case the product would be defined by using user needs, management goals and constraints of the actual market being the third variable.

Further work on the model could include:

1. Allocation of funds for facilities management on the basis of the values held by the model variables can be investigated to base the allocation on supply and demand factors of use.
2. The process model used here is a TO BE model or a functional architecture. A more comprehensive facilities management model should also include a framework for obtaining, AS IS process model to enable determination of reasons for problems and hence more effective service concept designs.

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