MODELLING THE COMPLEXITY OF MODERN CONSTRUCTION PROJECTS

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ABSTRACT:
The search for significant cost savings and quality improvements on construction projects is a routine activity and one where there is plenty of theory, but few results capable of being reproduced elsewhere. One reason is that the organisational infrastructure of a project is not always properly understood and defined, meaning that novel ways of bringing about such savings and improvements can be frustrated by invalid or erroneous assumptions. A case study of a large housing project, as part of a top level investigation by a government department, has shown how even domestic type of construction is not without problems in understanding the complexity of the process. The investigation is documented as a set of computer-based process models for the entire project, which have been used to pinpoint failures in communication and information management. Of particular interest are the early, pre-design stages (briefing) and the supply chain covering the off-site design, fabrication and assembly of components. The findings show that large parts of the process are not adequately defined. The parties had difficulty in agreeing upon the amount and specifics of the activities taking place, as well as the resources and information that were necessary for the project's successful completion. Conclusions are drawn that stress the need for clear and transparent guidelines and procedures.

KEYWORDS: process modelling, project information, project definition, supply chain

1. INTRODUCTION

Improvement in the construction sector is a topic of current debate. Enterprises, consultants and government are looking at ways of raising quality, lowering costs and shortening project times. This work is not going unnoticed by the clients of the sector who see the potential benefits for their own organisations. Expectations have risen and new ways of working are being promoted to emphasise teamwork and greater involvement of the client organisation. The nature of construction however makes it everything but a trivial affair. The number of actors involved, activities being undertaken and decisions to be taken contrive to make the process less than certain.

This paper describes the findings from a detailed case study conducted on a large Swedish housing project and offers suggestions on how a more effective process can be achieved (Atkin and Leiringer, 2000).

2. BACKGROUND

In 1996, the Swedish government initiated an investigation within the Ministry for Industry, Employment and Education. The aim of the investigation was to create long-term reductions in the costs for construction and maintenance of social housing, thereby reducing the cost of housing and increasing employment in the construction sector. A special committee of enquiry *Byggkostnadsdelegationen* (BKD) was created to undertake the work.

This paper is based on the findings from a case study conducted on one of the test projects initiated by BKD. The project in question consisted of the construction of three adjoining buildings with a total of 44 flats specially suited for elderly living. The work was undertaken as 'design and build' with the construction phase running over nine months. The main actors were a regular client of the sector and large construction company.

The project was initiated under the assumption that benefits would accrue from an open and transparent sharing of information between the actors. The main objective of this test project was to measure and evaluate how an increased collaboration between client–contractor–suppliers could influence the quality of the end product and the costs of production and maintenance.

3. METHODOLOGY

The method adopted for the research was based principally on a detailed analysis of the processes supporting the housing project. A single model of the project was created using computer software based upon functional modelling techniques. These were used to document activities, their relationships and associated inputs, controls, outputs and mechanisms (Feldmann, 1998; Karhu et al., 1997). The computer software product, BPwin, was used. It is based on the US IDEF0 Federal Information Processing Standard for function modelling.

Interviews with key project personnel were conducted in order to obtain a complete (or as near a complete) picture of the activities that were undertaken, the information flows that these needed and generated, and the resources that were necessary for their completion. It was assumed that the information flows and activities reported in these interviews had taken place in the manner described. To validate and refine the model, repeated visits were made to the site. These visits were observational and did not impede the work. Discrepancies from what was said in the interviews were picked up and errors and defects were noted. Furthermore, a review of the documentation produced during the course of the project, originating from both the client and the project team, was undertaken.

The model was compiled from a functional decomposition of the project as a whole. Views of parts of the model were generated and used to 'walkthrough' representatives from both client and contractor organisations. Where necessary, sections of the model were altered or adjusted and 'walked through' again to achieve as near a replica of real life as possible. The resulting model covered in excess of 80 A4 pages and took the form of an integrated set of hierarchical diagrams. From these it was possible to probe the detailed workings of the project and to identify areas in which further study was needed.

4. MAIN FINDINGS

The housing project was considered as a success overall and the main actors have agreed to continue their relationship in coming projects. However, a detailed analysis of the workings shows that large parts of the process not were adequately defined and that further improvement could be achieved. Phases in the process where this was especially apparent were the early, pre-design stages and the general management of the supply chain.

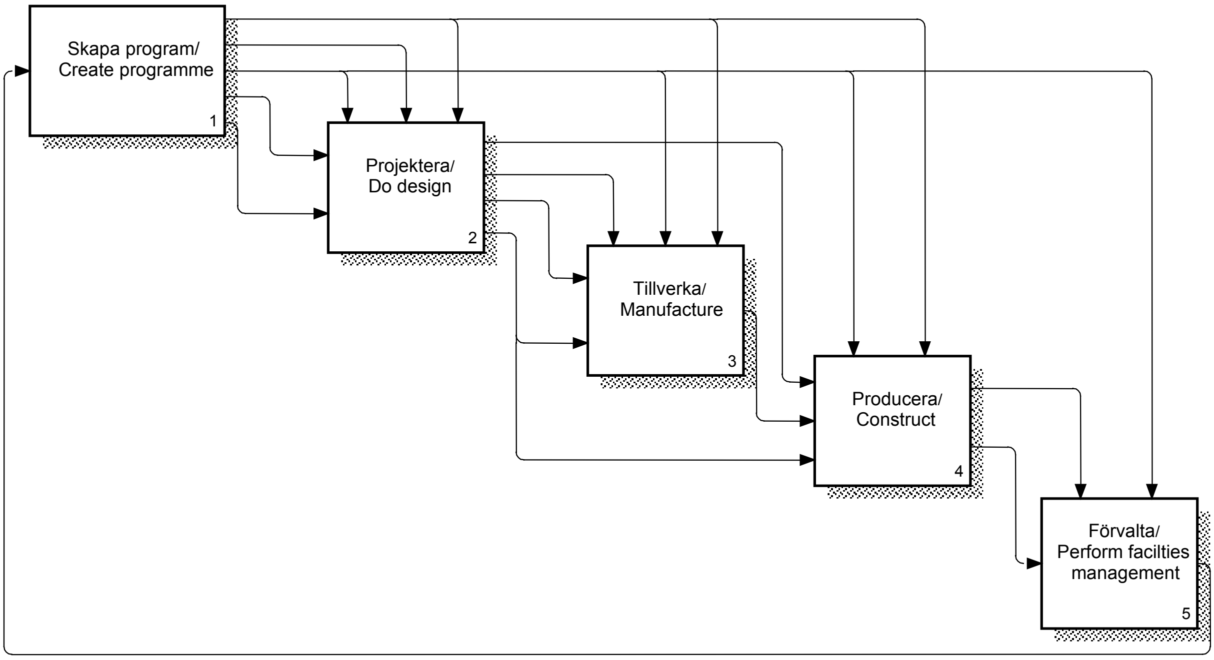

Figure 1. The five main stages in a typical Swedish housing project

4.1 Project initiation and definition

4.1.1 Briefing

The basis of the brief will normally be determined by requirements stated as objectives and priorities. Objectives generally take the form of statements as to the cost, time-scale and some (but probably not all) aspects of quality. The funds available will be fixed, as might the time for completion of the building. These objectives set the main working parameters for the project and challenge the team to produce the required quality. Unrealistic objectives for time, cost and quality and, equally, impractical trade-offs between them will inevitably result in a less than satisfactory outcome. Priorities should be stated in terms of which objective is of the greatest importance and how the others relate to it.

Some of the performance failures on this project could be traced back to the inadequate definition of needs and the relative ordering of priorities. One cause being that the project objectives and priorities were not recognised and shared by all members of the project team as they had not, likewise, shared the same views on the importance of early meetings and the exchange of information.

None of the workings of the process should be the private affair of any member of the project team. Bringing transparency to decision-making and, at the same time, throwing light on the actions required of each team member enables the project team to concentrate upon doing the job to the best of its ability. The use of a project plan, such as was developed on this project by the researchers, would help in ensuring that this becomes the practice (Atkin, 1999). The project plan must define the process – from initiation to occupancy – in such a way that the client can see what is to happen on the project. Moreover, the project plan must show clearly and unambiguously the actions, their sequence and times that are needed to complete the project. In the case study project it turned out that there were actors who had not recognised the full extent of the work that lay ahead of them. The effect was that they could not fulfil their commitments, which effectively impeded the performance of several other actors. A detailed project plan enables the full sequence of decision-making to be taken into account from the start of the project. This means fewer surprises and less risk exposure for the client through a more certain process.

4.1.2 Building the team

Project success derives largely from the actions and interventions of the various members of the project team and those associated with them. This may appear to be a self-evident statement, but it is too important to go unsaid. Total commitment of team members over the entire duration of a project may be difficult to achieve. However, there are some simple steps that the client can take to ensure that the team remains focused on the project objectives and priorities. Decision-making should be as transparent as possible and timely. Awareness of what each team member does is of paramount importance if communications and actions are to be effective. An explicit project plan would help each organisation and person to establish the required mode of working. Team members can then be expected to act promptly and correctly. A plan would also ensure that members are fully conversant with their roles and responsibilities and, equally important, that others are aware of them too.

The case study project, as most other building projects today, required the services of specialists. They were not needed just for constructing or assembling elements or components of the building, but also for undertaking parts of the design. Their work had to be integrated with that of others in, as is the nature of construction, a fast-moving and dynamic work environment. Managing the interfaces between various specialists requires close attention – certain failures in the performance of the buildings in the project resulted from mistakes made at the interfaces between components and/or the organisations responsible for them. Coordinating the work of specialists is a necessary task and one that has to be resourced adequately. Ensuring that the scope of work covered by respective specialists is complete is key to efficient development of the design – there should be no gaps. Visits to the design offices and works of specialists are highly recommended even though the specialist may only be responsible for a small part of the project. One such visit was made in the case study project. Representatives from both the client and the contractor visited the manufacturer of prefabricated modules. Even though it was meant as an information gathering visit important weaknesses concerning both structural and functional aspects of the product were discovered and passed to the manufacturer. The findings show that telephone calls and verbal assurances are not sufficient substitutes for a physical presence to check the facts. Subsequent visits, once the project is underway, ensure that there is no deviation from what has been agreed. Surprises generally result from a lack of return visits. Moreover, simple calculations show that the cost of the additional supervisory and management resources will be amply repaid.

4.1.3 Programme and time management

Timing of key decisions is likely to determine the pace of the project more than anything else. Bar charts and other graphical representations show when decisions have to be taken, but during the course of the case study it became obvious that they did not always help in understanding what must be done to enable those decisions to take place. It is therefore necessary to expand the role of project planning (i.e. programme and time management) to incorporate real-time decision-making.

The project plan – referred to earlier – is intended to show where in the process decisions have to be taken, who will be involved and the information required. It can be extremely helpful early in the project's life by acting as a checklist. Programmes in the form of bar charts and precedence diagrams will be used in conjunction with the project plan. The implications of a change of schedule, or design, can only be considered properly if there exists an understanding of the underlying processes and the flows of information and actions needed to maintain integrity of the project plan based on a comprehensive model of the entire process.

4.1.4 Risks

Practical steps to reducing or eliminating risks begin with a process that is visible to all parties and about which there can be few misunderstandings. Design brings with it many hidden risks that cannot always be identified until some time has passed. One of the commonest risks facing any project is that the constructability of a design may be insufficiently assessed prior to work on site. In the case study project it turned out to be impossible to achieve the required tolerances for the floor structure without undertaking additional work.

Bringing construction expertise into the project team early in the process helps, but there has to be a real commitment to identify risk continuously throughout the process. Risk assessment is not a one-shot event. The use of a project plan, which is shared by everyone, helps to identify areas of risk as well as keeping track of which actions are required when and by whom. Overall, this is likely to ensure that fewer items are overlooked. In practice this will need to be supported by a formal approach to risk assessment as part of a total risk management regime. An integral part of this is the establishment of a risk register from the very beginning of the project. Good business practice by the client, design consultants and the contractor would incorporate risk management as the norm. Bringing such practices to bear at the project level is also needed.

4.2 Managing the supply chain

The term ‘supply chain’ is used to describe the linkages between the various activities, resources and actors and the interactions between them needed to accomplish a given outcome, for example the transformation of raw materials into finished products. The research has shown that many of the root causes of problems on site lie in the complex chain of off-site purchasing, manufacture and logistics.

4.2.1 Partnering

There is no point in a client partnering with a construction company if the latter does not implement this practice throughout the supply chain. In the study, the contractor had difficulties in convincing a few suppliers of adopting the principles on which it based its work, one example being the application of Just-In-Time thinking. Reducing costs by eliminating inefficiency and waste comes about from a thorough understanding of how the present work is performed.

4.2.2 Logistics

Assuring the timely delivery of supplies and the arrival of specialists is an obvious factor in the success of any enterprise where materials, labour and machinery have to be coordinated. Even some fairly straightforward construction activity on the project went beyond the requirements of many industrial sectors in demanding the close coupling (or scheduling) of these key resources (or factors of production). When one talks of waste on a construction site, this extends to all three factors – materials, labour and machinery.

Greater effort can, as it was in the project, be put into the control of on-site activities to minimise waste. However, the same cannot be said of the ‘hidden’ off-site activities since they were generally viewed as being someone else’s problem. Synchronising the arrival of the right components, at the right time, with the right availability of labour and machinery will reduce wasteful working and lead to lower costs for the client. The way to ensure the correct synchronisation of deliveries with the demands on site is to regard this aspect of project management as deserving of appropriate supervision and management. This turned out to be a difficult concept to sell to the actors involved, despite the obvious imbalance between the cost of consequential delays and errors and the part-time employment of a ‘chaser’ or ‘expediter’. For the relationship to work and for the supply chain to function efficiently requires an organisational infrastructure that has checks built into it. Checks that, unlike those conducted in the case study project, are based on more than spoken assurances by the suppliers and assumptions made by the contractor that the work will be done properly. To say that failure of a trusted supplier will result in its not being considered for the next project is no comfort to a client who has a late and expensive building.

4.2.3 Delivery errors

Delivery errors that occurred in the project included the quantity of components supplied, their conformance with the specification and their arriving in the wrong sequence. It happened that the suppliers delivered components to site in a sequence or batch that suited their own production, but which was at odds with the requirements of the construction site. Construction companies need to ensure that not only is the delivery timely, but that the content is in accordance with the on-site production schedule.

The pursuit of zero delivery errors is only meaningful if there is action to follow this through. This requires that reasons be identified for the cause of the error. Simple causal analysis could be enough to ensure this happens, so long as the findings are recorded and implemented to avoid repetition. Once this practice has become routine – as in fact it must if one is working to a quality system – it is likely that many of the common, easily avoidable problems will disappear. One must, unlike in the case study project, avoid relying on individuals’ memories and, instead, hard-wire error avoidance into organisational procedures.

4.2.4 Quality failures

Tracking the cause of quality failures is routine in many industrial sectors. Knowing the real cause of a defect can lead directly to improvement in the product, process or both. In the case study project the plain truth was that all quality failures not were sufficiently quantified and analysed. More could and should have been done. It is obvious that going back and putting work right costs more than getting it right first time. The entire exercise would have paid for itself. Tracking back to the cause of the failure (or defect) is a part of any quality system.

Arguing that such action is bureaucratic surely cannot be defended: it would be like saying that if the client actually wants a proper job done then the client is going to have to pay more.

5. CONCLUSIONS

The research discussed in this paper is based on the detailed analysis of a housing project in which the actors have gone beyond their established procedures to create an open, transparent and, above all, collaborative atmosphere. The findings show that even though the project was judged as successful there were still plenty of unnecessary procedures and wasteful working. Improvement could be reached by the application of clear guidelines, i.e. a project plan, which would provide the actors with sufficient information regarding activities, information flows and resources. A more effective construction process comes out of all parties knowing what to expect and what to do. The use of computer-based IDEF0 functional modelling has supported the kind of analysis that is generally impossible by manual means, and led to hard evidence of how to bring about both savings and improvements.

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