OPERATIONS MANAGEMENT ON THE CONSTRUCTION SITE – DEVELOPING A HUMAN RESOURCE AND KNOWLEDGE ORIENTED ALTERNATIVE TO LEAN CONSTRUCTION

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In these years lean construction approaches is flourishing in Danish building projects. The Koskela (2000) concepts such as the TFV-perspectives (Transformation, Flow, Value) and the last planner (Ballard 2000) are directly used in attempts to rationalize building processes. One can receive this as a refreshing renewal and improvement of practical operations management at the site. However this paper will present a first step of development of a new approach to operations management at the building site, which at the same time builds on, and criticize lean construction for missing the point of the knowledge economy. This endeavour is carried out in two ways. *First* by a reading of the operations management literature. Juxtaposing this with lean construction extentions and the critique developed by other scholars. And also drawing on human resource management approaches. *Second* through a series of detailed observations of building site management at a building site, highlighting a number of "stumbling-stones" in the processes, that is events that interrupt or distract the building processes . The stumbling stones is analysed in a lean construction framework according to the "7 healthy streams" scheme.

In both directions it is revealed that the human resource and knowledge element of building processes is largely left untouched by lean construction methods. It is suggested to introduce at least two more dimensions of operations management at the site than the ones offered in lean construction; human resource issues (knowledge) and site management issues. The seven "healthy stream-s" focus on whether the human resources are available, but no not understand the competence and knowledge content. Moreover the empirical research revealed that site management themselves creating "stumbling stones" for the process. Henceforth not only employees, but also management need to rationalize within a renewed knowledge economy operations management.

Keywords: Operations management, lean construction, human resources, knowledge

INTRODUCTION

Operational activities and management continue to be of central importance in developing construction. Seen from a management perspective, organisational, quality and productivity issues on the site still are very important explanations for the lack of economic success for contractors, with important implications for clients, architects and consulting engineers.

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Koch, C (2004) Operations management on the construction site - developing a human resource and knowledge oriented alternative to lean construction. *In:* Khosrowshahi, F (Ed.), *20th Annual ARCOM Conference*, 1-3 September 2004, Heriot Watt University. Association of Researchers in Construction Management, Vol. 2, 1017-27.

There should therefore be a continual interest within construction management on operations strategy and operations management. While practical experience with lean construction flourish in several countries including Denmark (Thomassen et al (2003), Larsen et al (2003), Simonsen & Koch 2004), there seems to be a parallel paucity in construction management research on site issues. If ARCOM conferences are to be taken as a measure for this, ARCOM 2002 and 2003 conferences generally illustrate an instrumental diversity in issues, but the number of site studies are however comparably low (ARCOM 2002, ARCOM 2003). The contention of this contribution is that operation management on the site should receive contemporary interest in trying to understand the new conditions for carrying out operations. This first of all means that human aspects are too important in the knowledge economy to be left aside as is done in traditional operation management fixated on a view on processes as transformation systems (Rytter et al 2004). In other words there is a need for a stronger understanding than what is offered in lean construction approaches. Ultimately there is a need for a new more socially informed paradigm within operation management. The present contribution takes a more humble and exploratory step by combining recent operation strategy and management contributions from manufacturing with lean construction and social science elements. The empirical material is limited and focused on site manager's work and interruptions, failures and disturbances in this work. The paper further develops on the argument presented in Koch (2004). The paper is structured in a classical way as follows. It opens with a presentation of contemporary operation management, followed by the development of a tentative framework for understanding construction operations. Then follows a method section and the presentation of the case. Finally discussion and implication deals with possible new developments within construction operation management.

OPERATIONS MANAGEMENT AS THEORETICAL REFERENCE POINT

Operations management has its core in management of processes, operations that produce goods and services (Krajewski &Ritzman 2002). The industry focus of most operation management writings and research are manufacturing and services (see also operation management textbooks such as Chase et al 2000, Krajewski& Ritzmann 2002). The topics covered are a range where operations strategy, technology management, quality and operations planning and scheduling are the most prominent (Scudder & Hill 1998). Although several contributions maintain a focus on the production system and assign this as the area for operations management and exclude for example marketing and financing (Russell & Taylor 2000, Krajewski & Ritzmann 2002) others argue for the study of for example cross functional integration (Chase et al 2000, Sthub 1999) or the broader linkage between strategy, competitive priorities, manufacturing practices and operations (Boer 2003). The discipline is dominated by a systems theory perspective, according to which an operation is a transformation of an input turning it into an output (Russell & Taylor 2000, Sower et al 1997, Sthub 1999 a.o.). Several strands and new developments are present however (Boer 2003, Christiansen &Boer 2002, Sower et al 1997). Also methodologically operation management has become a more open platform giving space for empirical research (Scudder & Hill 1998, Sthub 1999 p1). Importantly there have been several serious attempts to renew and enlarge the theoretic basis. As examples consider Lewis (2003) who introduce and study competencies and Christensen (2003) who use critical theory to study the role of language in operational processes. Seen as a whole operations management has thus developed into taking quite a broad spectred set of issues and

areas onboard. As discussed in Marton & Koch (2002) operations management does not straight away offer conceptualization of construction operations under the new economies. The limitations are linked to the understanding of construction, operations, new economies and the paradigm used: *First* mainstream operation management does not deal with construction. But when embarking into construction research and theory-in-use in the construction sector, processes understood as transformation are quite prevalent if not dominant in construction (Koskela 2000 a.o.). Moreover planning techniques and other elements in construction are not that different from a mainstream operation management position. Construction is one-of-a-kind production so lot sizes, material requirement planning and other methods which assumes that the production of products has a volume do not apply however. Koskela and others in the Lean Construction discourse apply, what they label a TFV- approach that is a Transformation, Flow and Value view on processes in production. *Second* the TFV-position do not deal with new economy conditions and this a weakness shared with operation management mainstream. Two elements of new economy is important to target in developing operations management for construction; the globalisation and the centrality of handling of knowledge (Lundvall 1999, Lundvall & Borras 1998 a.o.). Globalisation challenges construction through restructuring of market for component supplier, the market for consulting engineering (Koch 2004) and the operations of contractors. Here however we will stick to Lundvalls point that the importance of knowledge underlines the local aspect of globalisation, since tacit knowledge and communities of practices have a strong local character, which means that handling knowledge inevitably has a local element. *Third* the new economies bring HR issues to the center of management concerns since the development of complex products with high content of service and knowledge implies a strong emphasis of making people cooperating and communicating. HR is however still not really part of operations management (Scudder and Hills (1998) and Sowers et al (1997)), even though the increasing emphasis on service operations commences changing this. Wright & Race (2004) thus introduce these issues, relying however on Maslow and Hertzberg, whereas Sthub promote the ideas of concurrent engineering by advocating for a team of experts across functions, job design is dealt with by Russell and Taylor, but in a traditional way (Russell & Taylor 2001) and without mentioning teamwork. Finally the paradigmatic embedding in system theory and realism is problematic. This is a shared impairing of operation management both in manufacturing and construction. The main problem is the underlying assumption of transparency and mono dimensionality of construction processes. Voss (1995), Rytter et al (2004) thus proposes a new paradigm conceptualising operations as a social arena of actors with bounded rationality, interpretations and interests.

A TENTATIVE FRAMEWORK FOR CONSTRUCTION OPERATIONS

We are now ready to offer concepts for understanding production in construction under conditions of new economies. The attempts to understand, model and control operational processes in construction have quite often ended up in the classical transformations model “input- transformation- output”, picturing operations as pearls on a string (Koskela 2000). Drawing on Campinos Dubernet and Coriat, Duc (2002) along with Carassus (2002) represents an alternative to that. They find double variability to be central for the understanding of building processes. Double variability is the combination of external variability due to heterogeneity of products and markets and the internal variability refers to handling live work with its flux in space and time.

The external variability creates complexity through unclear and emergent demands from the client and the characteristic fragmentation amongst companies in the industry; architects, technical advisor and contractors. The internal variability can be seen as occurring as a result of quantitative complexity; the products and process consists of a very large number of components and subsystems that need to be produced and assembled. Moreover designs of details are usually occurring overlapping with the execution period. This in total creates multiple and parallel processes. Parallel operations are at the same time interdependent and can therefore be expected to interrupt and disturb each other. In can be conceptualized as building processes encompass requisite parallelism and fragmentation due to their predominantly quantitative complexity. Construction processes therefore occur fragmented, interwoven, and with strong interdependencies. The operations share physical space, share abstract space (site management, negotiation and coordination) and the conditions are dynamically transformed over time. Interruptions are planned and unplanned. The characteristics are shared with other complex product industries such aerospace, shipyards, capital goods, infrastructure, in not having a repetitive element as the basis for operations management.

APPROACHING THE CONCEPTUALIZATION OF CONSTRUCTION OPERATION PROCESSES

In the study presented here the conceptualization of the building processes needed to be applicable as a basis for an exploratory approach. It was therefore chosen to adopt a tentative framework. In Lean Construction principles the notion of a “healthy stream” is introduced (Koskela 2000, see also Jensen et al 1997). The argument is that a well executed operation need to encompass the following seven sub elements:

- Connecting and preconditional work (properly finished)
- Space for executing work
- External conditions
- Equipment and machinery
- Materials and components
- Workforce
- Project material (construction design)

The healthy stream dimensions can be seen as an instrumentalisation of the external and internal variability. In order to reduce disturbances and failure the operation managers (site managers and foremen) need to check for external factors (such as the weather conditions) as well as internal ones (ex. the workforce). The framework is focusing on the execution of production operations, whereas the design of the product is not directly incorporated. We needed to incorporate those and in doing so we drew on a Danish government programme “Projekt House” which proposed to use basically the same seven dimensions for the design process, which elevates the framework two times seven analytical dimensions; seven for design and seven for execution. There was and is however a major problem in the lean construction conceptualizations of a healthy stream or operation. It overlooks how profound the processes are dependent of and processed by humans. It has been a recurrent critique posed by amongst others Green (2001) and Christensen (2002). Green thus argue that the HR-dimension has been cleansed out by lean construction proponents, whereas Christensen at a lower volume but insistently point at the hidden assumptions on systems theory operation

approaches of a “inbuilt” coordination between transformations.Coordination is moreover a recurrent explanatory elements in broader description of (problematic) practices of building processes. Söderberg thus uses the metaphor of a “relay race with bad exchanges” (Söderberg & Hansson 1993), Duc even distinguish between organisation and (real) cooperation, which she argue occurs amongst workers in everyday work (Duc 2002). In order to take these HR-dimensions into account a “HR co-operation, co-ordination and competence” dimension was introduced. The dimension was defined in a broad manner in order to allow the exploration of these dimensions in the operations. The tentative analytical framework thus consists of 8x2 elements of processes. Used as analytical tools means that the healthy stream, is transformed into an analytical aspect of operations. Within those dimensions of the operations the focus was to observe disturbances and failures. Here the definitions of disturbances and failures as “stumbling stones” was used (Kjeldsen 1994). Stumbling stones according to Kjeldsen are “ all the issues that prevents the actor in executing his work as effectively as possible and as right as possible the first time”. As noted before building processes exhibit requisite parallelism and mutual interdependency, which implies that some interruptions can be seen as instrumental. Therefore not all interruptions in processes necessarily lead to problematic events and it is preferred here to use the term disturbances. Finally it is distinguished in the framework between failures and disturbances that occur as specific for the process followed or whether they have general character.

METHOD

The present paper takes construction management as approach. The perspectives developed on building processes combines elements of operation management, organisational sociology and production engineering in a multidisciplinary manner. The theoretical frame for understanding operational building processes draws on a modified lean construction conceptualization of the steps and interdependencies in the process. The more profound implications of using such a combination in terms of differences in epistomologies are not discussed further here. The empirical material used stems from several sources in an ongoing research cooperation with a major design built contractor. The central material stems however from Nielsen & Apelgren (2003), a master thesis from two civil engineers, one of the now employed at DTU as a research assistant. They carried out the participant observation and interview in the exploratory field study reported here. A site was chosen with a representative from the contractor. The present portfolio of project within the contractor was the possible alternatives. The present site was chosen because it represented an assumed average building processes which was active at the time of the study. Participant observation cover 7 Managers, 1 Architect and three meetings on the site, one observation was carried out as walking around on the site. Finally written documentation from the project was used. 17 observations were carried out during two months. The following actors were followed

Project coordinator (1 observation)
Foreman (3 observations)
Production manager (1 observations)
Subcontract manager 1(2 observations)
Subcontract manager 2 (2 observations)
Overall project manager and controller (2 observations)
Design manager (2 observations)
Architect (2 observations)

The conceptualisation of operations was further developed through the exploratory field study of operations at a site. We are thus currently working on a project on building processes, which will benefit from and develop these first results.

CASE: THE EARLY PHASES OF A BUILDING PROJECT

The project studied was one subproject out of a larger cooperation between a municipality, and a network of construction actors; a design built contractor, an architect, a consulting engineer and a client's counselor. The overall project aimed at renewing and enlarging the public school services of the municipality (see also Koch et al 2004). The focus here is however on the building of one new school. This sub project amounted to 12 mil. Euro for the contractor out of a total project budget at 26 mio Euro. Whereas the architects and consulting engineers has a common budget for the entire project at 2,6 mil. Euro. The project began in the late nineties. The conceptual phase lasted from October 2001 to May 2002, followed by a design phase. Production of the school commenced September 2002.The observations was carried out in September and October 2002, thus covering the early part of foundation works. The new school was finalised in October 2003. Operation during production was planned using traditional project planning tools (Microsoft project), accompanied with regular meeting and evaluated by a key performance indicator scheme. Lean construction principles were not used. It should be underlined that the project not as a general feature demonstrated stress like tight budget frames or delays, including the one studied in the field work, whereas it did occur in smaller periods of time. The project was finalized on time and with a small surplus compared to budget. Schools as a product are characterized by a mixture of repetitive and innovative elements. Especially the production of classrooms, but also other special function rooms are the repetitive elements, whereas the sports facilities in this case were an innovative challenge. The complexity of the product can be characterized as moderate. The Operation manager team included the following: Project coordinator, foremen, production manager, 2 Subcontractor managers, overall project manager and controller and design manager. All the mentioned members come from the design build contractor. Out of these two managers worked predominantly with production issues and the rest worked predominantly with design issues, although these issues were interwoven. The site had 13 employed craftsmen and building workers in the beginning rising to 79 at the end of the projects. The design project group overlapped with the above mentioned but also encompasses members from the architects and the consulting engineers. The results of the study show very fragmented activity patterns over time. Normality is a typical workday with 3-4 primary activities, but with some 126 disturbances and the extreme observed was 171 disturbances. For example the subcontractor manager experiences at one work day 20 disturbances including the following:

-receiving a employee call saying his is sick
-PC breaks down, when trying to open excel
-receiving call; that part of the outdoor design is delayed
-meeting with subcontractors, where no one shows up
-attempted call for the headquarters, wrong number
-during a round on the site receives call on mobile from site management

Disturbances and failures occurred in a number of areas during the observation. A distinction between general failures such as potential errors in drawn material and specific errors such as a delay in the arrival of a specific schedule was used both under

design and excution. A typical example of an execution stumbling stone is the late arrival of wooden roof cassettes from the supplier and a breakdown of a piece of machine equipment. Below the stumbling stones are listed:

Disturbances and Failures		**Aspects of design operations**
Specific	General	
6	-	Connecting and preconditional work
-	-	Space
-	-	External conditions
4	-	Equipment
19	4	Information
5	-	Workforce
6	-	Desicions and documentation
20	11	HR – cooperation, co-ordination and competence

Table 1 Distribution of observed disturbances and failures in design.

Disturbances and Failures		**Aspects of execution operations**
Specific	General	
1	-	Connecting and preconditional work
-	-	Space for executing work
7	-	External conditions
3	-	Equipment and machinery
7	-	Materials and components
2	-	Workforce
9	1	Project material (construction design)
15	7	HR – co-operation, co-ordination and competence

Table 2 Distribution of observed disturbances and failures in execution.

The design and execution tasks did not occur as well separated activities, but where mingled in the work of site managers. Moreover in some observations it occurred that site managers were involved in preparing bids for other contracts than the one they presently worked on.

DISCUSSION AND IMPLICATION

These results tell something about operation management's condition in construction operations. The operation managers are attempting to bridge and mediate a number of recurring processes, A large number of failures, disturbances and interruptions occur over time. The present set of observation are limited to a short period of the beginning of the project, but results can be underpinned by Josephssons (1994) and Josephsson & Hammerlund (1996), which shows a continual high number of stumbling stones throughout a building process. A similar result is found in our current research on

another Danish building site. As already noted the observed project did not demonstrate stress like tight budget frames or delays. The project was finalized on time and with a small surplus compared to budget. Had these types of stress occurred it would probably have led to an increase in disturbances and failures. Another observation is that it was indicated that apart from the two types of variability, external and internal it also occurred that site managers had to tackle a third type, the one from other projects running in parallel with the present.

There is a set of normative implications as well as issues for further research. One set refers to changes in the relationship between site managers and operational workers when carrying out operational management together: Lean Construction encompass a set of tools especially last planner, which responses to requisite parallelism, fragmentation and the quantitative complexity, by splitting the planning task into smaller units closer to operations and with foremen (first level site managers) as planners and controllers evaluating on work carried out. This strategy implies development of competences amongst first level site managers and shifting emphasis internally in site management to a lower level. Nevertheless the frequency of meeting far from meets the coordination needs demonstrated by the present case study. Ducs (2002) normative implication of her site study is therefore interesting. In her analysis of site management, Duc describes how work organisation is done with what she denotes “floue” prescription, which can be translated with unclear, fuzzy or vague prescriptions (Duc 2002, p65). Given the characteristics of construction works, the analyses says that the lower you get in the hierarchy the more you have to adapt to diverse constraints, the less you can follow prescriptions. The fuzzy, vague prescription is thus a necessary tool for realising a margin for workers to adapt and let space for them to create and take in charge the flux and variability in work. The fuzzy prescriptions are thus not to be seen as incompetence by management but the right out opposite. And the necessary competence is thought of as being developed amongst the craftsmen. In other words it is important to see the response to fragmentation and quantitative complexity could be a cooperative one. Haas (2003) conceptualise this difference through what he labels Tier I versus Tier II strategies of deploying work. Haas points at developing workers skills for coordination and communication as an (possibly indirect) alternative to the lean construction upskilling of foremen. Another important point for Haas and his colleagues is the development of HR-strategies of the contractors enabling them Burleson et al (1998). Moreover the empirical research revealed another set of normative implications focused in internal site management activities: Site management themselves creates “stumbling stones” for the process and reorganization could also focus on strengthening the site management team. Henceforth not only employees, but also management need to rationalize within a renewed knowledge economy operations management.

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