

# **MANAGING THE THREE ASPECTS OF PRODUCTION IN CONSTRUCTION**

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## **ABSTRACT**

It has been argued that production can be conceptualized in three complementary ways: transformation, flow and value generation. In production management, each of these aspects should be tackled. The interactions of these three kinds of managerial work provide for further generic managerial tasks. Also the contingent nature of management has to be taken into account. Based on the essential characteristics of construction, an ideal type of management of each aspect is presented. The paper ends with practical examples where the different types of management as discussed have been explicitly deployed. The managerial model outlined contrasts with the conventional managerial practice where only transformations are explicitly attended.

## **KEYWORDS**

Production management, project management, transformation, flow, value

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## **INTRODUCTION**

It has been argued that production can be conceptualized in three complementary ways: as transformation, as flow and as value generation, and that in production management, each of these aspects should be simultaneously tackled (Koskela 2000). The conventional conceptualization of production within construction has been based on the transformation concept only. The question thus arises: How, in practice, can we introduce the new concepts into the management of construction projects? This paper endeavors to give an initial answer to that question.

The plan of the paper is as follows. First, we recall the basics of the TFV approach. Next, the interactions of these three kinds of managerial work are defined, providing for further generic managerial tasks. Based on the essential characteristics of construction, an ideal type of management of each aspect is presented. The paper ends with practical examples where the different types of management as discussed have been explicitly deployed in the construction context.

## **THE TFV APPROACH**

### **THE CONCEPTUAL FOUNDATION**

Historical analysis reveals that three different conceptualizations of production have been used in practice and conceptually advanced in the 20th century. In the first conceptualization, production is viewed as a transformation of inputs to outputs. Production management equates to decomposing the total transformation into elementary transformations, tasks, and carrying out the tasks as efficiently as possible. The second conceptualization views production as a flow, where, in addition to transformation, there are waiting, inspection and moving stages. Production management equates to minimizing the share of non-transformation stages of the production flow, especially by reducing variability. The third conceptualization views production as a means for the fulfillment of the customer needs. Production management equates to translating these needs accurately into a design solution and then producing products that conform to the specified design.

It is argued that all these conceptualizations are necessary, and they should be utilized simultaneously. The resulting transformation-flow-value generation model of production is called the TFV theory of production. In production management, the management needs arising from the three concepts should be integrated and balanced.

As a first step towards integration, we can conceptualize production simultaneously from these three views: transformation, flow and value generation. An overview of such an integrated transformation-flow-value generation concept of production is presented in Table 1. Let us call this model the TFV theory of production, made up of the T, F and V concepts (or T, F and V views) and associated principles. The crucial contribution of the TFV theory of production is in extending its attention to modeling, designing, controlling and improving production from all these three points of view. Regarding practical management, let us call the domains of management corresponding to the three views task management, flow management and value management.

Table 1: The TFV theory of production (Koskela 2000).

	<i>Transformation view</i>	<i>Flow view</i>	<i>Value generation view</i>
<i>Conceptualization of production</i>	As a transformation of inputs into outputs	As a flow of material, composed of transformation, inspection, moving and waiting	As a process where value for the customer is created through fulfillment of his requirements
<i>Main principle</i>	Getting production realized efficiently	Elimination of waste (non-value-adding activities)	Elimination of value loss (achieved value in relation to best possible value)
<i>Associated principles</i>	Decompose the production task Minimize the costs of all decomposed tasks	Compress lead time Reduce variability Simplify Increase transparency Increase flexibility	Ensure that all requirements get captured Ensure the flowdown of customer requirements Take requirements for all deliverables into account Ensure the capability of the production system Measure value
<i>Methods and practices (examples)</i>	Work breakdown structure, MRP, Organizational Responsibility Chart	Continuous flow, pull production control, continuous improvement	Methods for requirement capture, Quality Function Deployment
<i>Practical contribution</i>	Taking care of what has to be done	Taking care that what is unnecessary is done as little as possible	Taking care that customer requirements are met in the best possible manner
<i>Suggested name for practical application of the view</i>	Task management	Flow management	Value management

### HOW TO OPERATIONALIZE THIS CONCEPTUAL FOUNDATION?

Thus, we have three different sets of principles, partly contradictory, on the basis of which we can design, control and improve our production system. Which principles should be used in a particular situation? We propose the following guiding rules:

- *Integration*: The three views on production are aspects of the same phenomenon, and thus in each managerial situation, all the aspects should be acknowledged.
- *Balance*: In case of contradictory principles, there should be a balanced decision.
- *Synergy*: The synergy between principles should be taken into account and utilized in managerial decisions.
- *Contingency*: It depends on the situation, which view or particular principle becomes critical for success. All aspects have not necessarily the same weight in each situation.

### ILLUSTRATIVE ANALYSIS

Let us illustrate using a project, where (somewhat unrealistically) the customer needs are perfectly clear, but we have to create the production system and produce the product needed.

The first stage is to design the product and create the production system. The starting point is value management: we analyze the needs. However, the attention turns soon from value to tasks for investigating what has to be done. Then, we select the outside parties to

perform the tasks and agree contractually with them. In this stage, the primary attention is on task management, even if we make preliminary plans taking flows into consideration too.

The second stage aims at producing the product needed. We start by planning the production process in more detail, taking into account the task interdependencies and inflows to tasks. Next, we execute the plan, and here our focus turns to flow management: we try to ensure that materials and work flow smoothly and as planned. These flows, in turn, create both the product as well as the project outcome in terms of costs and time, and eventually the customer's satisfaction.

Thus, the main cycle of managerial attention seems to be value management – task management – flow management – value management.

In addition, we can identify the critical interfaces between these managerial aspects.

- The interface Value – Task concerns the preparation of WBS, contracting and contract management. What should we do for ensuring that the value we are aiming at will be realized by the contracts we agree upon?
- The interface Task – Value is about the classical quality view, i.e. conformance to specification.
- The interface Task – Flow is using teambuilding, which is necessary if we look upon the construction site as a virtual enterprise.
- The interface Flow – Task is about ensuring that the flows provide the prerequisites that are needed by the tasks.
- The interface Flow – Value is the management of the delivery of value to the client, not least flow value (time, costs etc.).
- The interface Value – Flow deals with the issue whether the user requirements are clear at the outset or not. If not, this has implication into how we configure the flows; the customer has to be incorporated more than usually. Another aspect to be considered is whether customer needs require extraordinary flow solutions, such as fast tracking.

However, we emphasize the contingent nature of the project: sometimes flow considerations accentuate, if the production system consists of complex and uncertain flow, sometimes value management, if client requirements are not well understood. Thus, we have to analyze the production situation for its characteristic features in order to decide on the managerial strategies required<sup>3</sup>. What follows concerns average, mainstream construction.

### **THREE PART PROJECT MANAGEMENT IN CONSTRUCTION**

In the following, we outline a method for operationalizing the TFV conceptualization in construction. A three-part management is proposed putting independent but coordinated focus on different objectives for the project management.

The TFV model shows that construction should be understood as a generation of value for the client. This takes place through a series of processes; forming a workflow drawing on transformations delivered by the trade contractors under a contractual arrangement with the client – either directly or through a general contractor.

We have thus a loop and not a direct up-down relationship between the value delivered and the work undertaken, as it is usually interpreted (Figure 1).

The traditional project management – here renamed Contract Management<sup>4</sup> – creates and maintains the relations between the value as defined in the drawings and specifications and the operations (as well as associated production capacities and materials) needed for the

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<sup>3</sup> In addition, there may be requirements set to production management by higher level systems, such as company strategy or technology strategy. These are not addressed in this paper.

<sup>4</sup> We use here the terms adopted in the Danish practice. This equals to task management of the TFV model.

delivery of the project and to be performed by the contract parties. The Process Management<sup>5</sup> undertakes the role of coordinating the production flow (as well as the flow of information, materials and equipment) as expressed by the processes through which the product flows towards its final form. And thus it is the process that deliver the actual value to the client, managed by the Value Management.

The roles of each of these three management functions are dealt with in more detail in the following with a focus on the construction phase particularly. But it can immediately be seen that the contract management manages the setting up of the production system needed for the project in question<sup>6</sup>. The process management takes hand of getting this production system to produce the project, and the value management takes hand of ensuring that the value delivered fulfils the client's needs.

Besides the objectives outlined in the following, an ongoing improvement must be part of the whole management system.

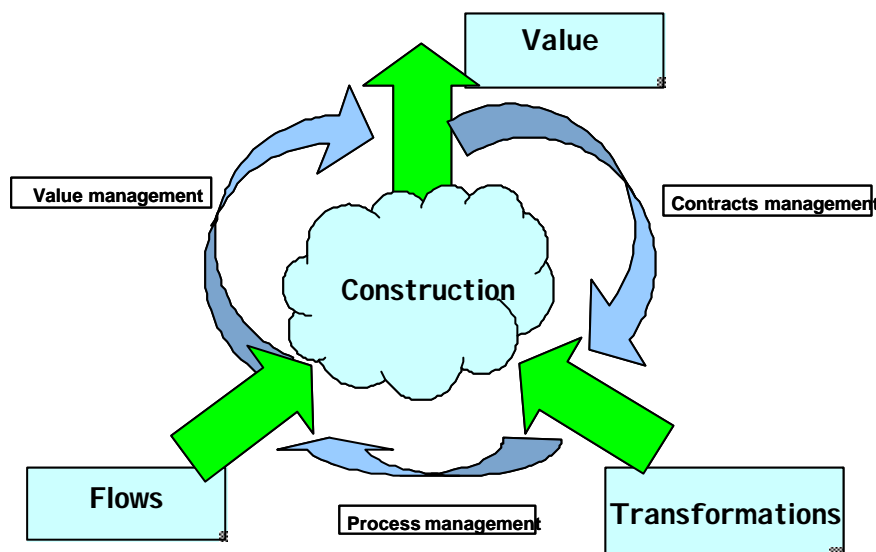


Figure 1: Three part management in construction

## CONTRACT MANAGEMENT

### Objective

The Contract Management's objective is to manage the individual and customized contractual arrangement, which is always associated with construction. Being one-of-a-kind production with a temporary production organization, this management is of a greater importance than probably found in most manufacturing industries.

Management of contracts may also comprise – and do so sadly often – management of claims and of penalties, besides the more fruitful management of payments and bonuses. The Contract Management takes hand of the target days, delays and punch lists, etc., as well.

Timely hand-over, low costs and a zero punch list are criteria of success for this management.

### Nature of the management

The Contract Management is a hard function. Often negotiations with big money involved will be part of the management and the style can be very harsh indeed. The complex nature of

<sup>5</sup> This equals to flow management of the TFM model.

<sup>6</sup> Here we discuss the main roles of each kind of management, Surely there is overlapping, for example tools of Contract Management may be used in Process Management.

the system may make construction look like a war, where all fight all other. Prisoners' dilemma leads to a cheat-or-be-cheated situation and the contract management must act as the ultimate umpire in this game.

The contract management is a very formal management as well, where a lot of rules must be adhered to. The management is most often executed indoors, either at the construction site or at the home office.

### **Management Tools**

The Contract Management's tools are the contract, requests of various kinds, work orders, organizational charts and master schedules etc. Also the formal quality assurance system is part of the contract management.

## **PROCESS MANAGEMENT**

### **Objective**

The Process Management has a predictable production flow with a high efficiency as its main objective. Criteria of success are also to avoid making errors and to eliminate the sources of these.

These are the formal objectives, but there is probably a more important objective behind them: The establishing of a fruitful cooperation between the parties working at the construction project and between the site workers particularly.

### **Nature of the management**

The Process Management is a mediating management putting cooperation, respect and compromise at the front. In its nature it is a soft type of management<sup>7</sup>. It is not its aim to be the best, but getting all involved on an equal basis. No chain is stronger than its weakest link.

It is a management that to great extent is executed on the spot – management by walking around, and most of its actions take place at the work site – not down in the shed. Making the worker move indoor creates an additional barrier between the process management and the crew, which the process manager can do without.

### **Tools**

The most important formal management tool is probably the Last Planner system with the PPC (Ballard & Howell 1998). Also productivity indicators showing where the barriers for an even workflow are, is part of the toolbox besides the five times Why and the list of stumbling stones. Poka Yoke methods are not very much used in construction but should be considered as a part of the process management tools. The informal tools are ways of getting people to cooperate, for instance the use of promises as proposed by Macomber (2001); and actions such as kick off and time out meetings are ingredients in the establishing of the daily cooperation.

## **VALUE MANAGEMENT**

### **Objectives**

The Value Management ensures that the construction process generates the value wanted by the client. As most of the product value is defined through the design, the Value Management during construction mainly looks after the process related value such as timeliness, dialogue with the owner, users and other stakeholders, public relations and good neighbourship.

Customer satisfaction is the most important criteria for success.

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<sup>7</sup> Women most often undertake it in the Danish implementations.

## **Nature of the management**

The Value Management will often be close to marketing and service. It is important to understand the client's expressed and tacit value parameters and make sure that the project fulfils these parameters as well as possible.

It is not the hard kind of management one finds in the Contract Management neither the soft Process Management style. Value Management is all about giving the client best value for his money, and this value will often comprise aspects looking irrational for the project team but be of great importance to the client. Accommodation to client-initiated changes, and learning during the project, are other forms of value management.

The Value Management thus acts in a soft, service oriented way towards the client and in a more hard way towards the production system, which by nature is much more focussed on fulfilling the contractual terms than on generating process value.

## **Tools**

The authors are not aware of formalized tools for the execution of the Value Management during the construction phase. QFD is aiming at the design process, but how does one manage process – or service – values?

During the Danish implementation a value management system has been proposed along with certain guidelines for the continuous monitoring of the process value delivered. Also questionnaires trying to identify customers' satisfaction have been introduced. Frequent time outs with the client and his stakeholders to evaluate the process and remove bigger or smaller obstacles may be another tool.

## **IMPLEMENTATION CASES**

### **MT HOEJGAARD**

The biggest Danish general contractor: MT Hoejgaard has established a company wide program for the implementation of Lean Construction under the trademark TrimBuild®.

They have introduced the principles and methods to more than 350 employees from top level management and down, and they have set the target that all new contracts with a contract value exceeding app US\$ 3 – DDK 20 million – shall be planned and executed in accordance with the new principles (Christoffersen et al 2001).

The above model has been used in the implementation with great success. Project management consists of two fairly independent functions: the contracts management and the process management. The two persons in charge work close together and coordinate their efforts – they are seen as Ying and Yang or as a bad guy/good guy team. Briefly it can be said that the contracts manager takes hand of most of the usual project management tasks, whereas the process manager takes hand of the teambuilding between the workers across the gang borders and of the work assignment in the Last Planner method.

At the middle of 2002, app. 20 projects has been completed or are in progress using these principles.

The company has not announced detailed results from this effort. However, it has been claimed informally that they have increased their productivity with at least 10 percent, that they have raised their own, their trade contractors' and the workers' earnings with ten to twenty percent, and that they have increased workers' safety substantially.

### **NIRAS**

One of the biggest Danish consulting engineering firms NIRAS has introduced the new management model as well. Their experiences are the same. Site productivity goes up and earnings are increased all the way round.

They have also tried out the formal value management in half a dozen projects with great customer satisfaction registered in surveys undertaken.

The reason for this success may also be that they – as a consequence of the value focus in the early design phases – have developed a new design process with respect for the wicked nature of building design. They work close together with a fairly big group of stakeholders representing all the aspects of the project, often including the planning authorities. The work takes place in the form of workshops, often with duration of more than one day. The number of participants are fairly high, often more than fifty, and besides the value manager, an independent process manager acts as facilitator during the sessions.

## **DISCUSSION OF IMPLEMENTATION CASES**

The new approach to project management has been an integral part of almost all lean construction projects executed in Denmark. However, there is still no single project having implemented all the aspects. And no formal reporting has as yet taken place.

All projects report a great success in terms of lower costs, shorter construction time and lower accident rates. The clear division of the management responsibilities is claimed to play a substantial role in this success. These statements are in a number of cases substantiated by detailed questionnaires used in monitoring the usefulness of the tools being answered by workers along with foremen on the site while the work is still proceeding as well as after the completion.

## **CONCLUSIONS**

Our theoretical and practical considerations indicate that it is worthwhile to implement the three aspects of project management separately, and to allocate the responsibility of each aspect to different individuals (provided that the size of the project makes this possible).<sup>8</sup> There are two major causes for this. Firstly, two aspects, value management and process management, are being introduced as new ingredients, and they may be easier to implement as add-ons to the present contract management, which thus remains more or less intact. However, it may be that in the future more integral theories and practices of management will be created, and the weight of this motivation will diminish.

Secondly, it can be argued that the nature of management in each of these aspects is so different that also different personalities are needed for the corresponding managerial positions.

Recent experiments with this kind of project management partly or in whole have shown remarkable results in the form of improved production, shorter production time, lower costs and a higher client's satisfaction. It is the authors' feeling that many of the characteristics of this new kind of project management can also be found in most of the successful implementations of the lean principles in other countries, even if they are not recognized and formalized as in the Danish implementations.

However, even if effective, the solutions described are still somewhat rudimentary and unsystematic. Clearly, more empirical and conceptual research is needed for finding robust and advanced solutions to these questions. A more detailed description of the interface tasks between the three aspects of management is one actual research issue. Another important theme is to link the three aspects of management, as discussed here, to the various categories of management (management-as-planning, management-as-organizing, management-as-adhering and management-as-learning) (Koskela 2001).

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<sup>8</sup> MT-Hoejgaard is studying the use of teams consisting of a contracts manager and a process manager to undertake several projects in parallel.

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