LAST PLANNER IN A SOCIAL PERSPECTIVE – A SHIPBUILDING CASE

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ABSTRACT

This paper addresses the implementation and use of Last Planner System for production control to improve workflow reliability in a Norwegian shipyard. The paper clarifies the adjustments made to adapt this system and particularly stresses the difficulties and challenges faced during the transformation from a rational operation-oriented to a process-oriented approach to production planning and control. The paper suggests that to benefit from employing Last Planner, making a system of collaborative improvement must be part of it.

More generally, the paper is a first step to a deeper understanding of why Last Planner works from a sociological point of view and in investigating its application to other types of project production.

KEY WORDS

production control, project production, people, culture and change, last planner

INTRODUCTION

Last Planner System™ is the system for production control developed by Ballard (2000), to improve workflow reliability in the architectural/engineering/construction (AEC) process. The system has proven an effective tool for improving the productivity in construction (Alarcon et al. 2002, Thomassen 2002, Thomassen et al. 2003, Ballard and Howell 1997, Larsen et al. 2003). This paper explains why Last Planner may also be relevant for the shipbuilding industry and how it may be adapted here – and indeed probably be used in almost any sequential project production. The paper suggests a system of collaborative improvement to be added to Last Planner promoting collective learning through a process of adaptation, formative evaluation and systematic reflection (Macomber 2001, Howell et al. 2004, Elsborg et al. 2004). This is concluded on the basis of observations from a case study of one shipyard and its attempt to apply Last Planner.

In pursuing a process-oriented approach to the management of shipbuilding, two questions must be answered:

- What characterizes a process-oriented approach to complex project management?
- How can a process-oriented approach be applied to shipbuilding?

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The paper introduces briefly the shipbuilding work flow, followed by an outlining of literature in the two areas of research, and an account of the methods that constitute the case study. The analysis section explains the change from an operational-oriented to a process-oriented approach to shipbuilding management. Typical difficulties and challenges faced during this transformation and possible ways of handling them are dealt with.

The paper is a part of a sociological PhD study at the University of Oslo, Centre for Technology, Innovation and Culture, Norway.

SHIPBUILDING

Shipbuilding – at least in Norway – is a complex project production comprising planning, design (basic, detailed and shop drawings), material specification, procurement, production (hull, pre-dock work, docking, outfitting and testing) and hand over, activities that must be performed in an overlapping and parallel manner in order to reduce the overall production time. It is a one-of-a-kind production, because there are typically substantial differences in design and specification between individual ships. Even when ships are built in small series, each ship is customised to the owner's specific requirements. Furthermore, detailed design and shop drawings seldom exist before the commencement of production, and design changes occur frequently during construction.

The shipyards rely heavily on a complex network of suppliers of components, and an increasing part of the production is performed by trade contractors. Testing the vessel and all its advanced components, sea trials and delivery is also a much more complex process than seen in most construction.

Shipbuilding is thus a highly complex, multi-phase, and multi-actor process including numerous operations, several disciplines (design, engineering, planning, procurement and production), quite a few functional trades and a wide range of suppliers, making it similar to the construction process. At the heart of the management is the coordination of multiple agents, each of which – just like in construction – is likely to pursue their own agenda (Bertelsen and Sacks 2007).

To the complexity of the task must furthermore be added the notion that decision-making in many circumstances is based on a "bounded rationality", given the unpredictable pattern of the project environment and the general lack of capacity to collect, store, process and retrieve all information that might be relevant to a particular decision. Nevertheless, the traditional management of shipbuilding may be said to rely heavily on the idea that plans may serve as programs for action, where reasoning about activity has not sufficiently taken into account the change of the circumstances set out at the start as the work proceeds.

PRODUCTION PLANNING AND CONTROL: THE HUMAN FACTOR

The Last Planner System of production control (LPS)[1] aims to improve the workflow reliability of temporary and complex production systems. LPS has

[1] Last Planner is a Lean Construction Institute trade mark.

as its starting point that the complex and dynamic environment makes the production uncertain and the feeding flows uncertain, wherefore reliable planning cannot be made in detail much before its execution, and where measuring Percent Planned Completed and identifying root causes for non-completion, establish a continual learning. In order to make work packages ready, look-ahead schedules are created to control the flow of prerequisites on a longer-term basis – a logistics for not least information, materials, equipment and crew – in contrast to traditional production planning, where work packages are pushed into the process based on target delivery or completion dates. Making assignments ready in the look-ahead process opens for work packages to be pulled by the Last Planners (foremen, squad bosses) into the production process only if the process is capable of executing them (Ballard 2000, p. 11).

The look-ahead plan – as a level of coordination between the master schedule and the weekly work plan – is a valuable contribution to production planning and control in complex projects. Although informative in terms of how the system may work under various conditions, and impressive with the results achieved from its implementation, most case studies suffer from leaving out the human factors involved in production planning and control. Ballard is quite clear about the topic of his thesis being engineering management and belonging to the general field of technology (op. cit., p. 41). When that has been said, there are elements included as parts of LPS that definitely have implications for social issues, such as the introduction of a new hierarchical level of production preparation (the look-ahead process), change in final decision (the requirements from the foremen or squad leaders in production becoming commitments to the rest of the organisation) and not least the shift in focus regarding production control (from issuing tasks to controlling the flows that links them together).

In an article by Johnston and Brennan (1996), on planning and organising as parts of management at the operational level, the following simple statement opens the paper: "It is one thing to think about doing something, but quite another thing to do it" (op. cit., p. 367). The article differentiates between what they refer to as management-by-planning, and *management-as-organising*[2]. While management-by-planning is referred to as being based on the widely held, but naïve, conception that everyday activity itself is mediated by representations of the world and effected by the implementations of plans, management-as organising has as its basis a broader definition of operation management including attempts to coordinate and control purposefully on-going activity of systems generally – whether they are mechanical, socio-technical or inter-organisational systems (op. cit., p. 368). The article criticises thus the activity planning model that dominates today's operational management, where a high degree of continuity, predictability and causality is ascribed to the world as a result of the assumption that formal deduction can lead to a valid prediction of future world states (op. cit., p. 371). Bertelsen et. Al (2007) discusses the same idea:

[2] Cf. Koskela and Howell (2002)

that the mental models used in most project planning are far too simple for the real word. Johnston and Brennan (1996) introduce an alternative model, the situated activity model where the operation manager is seen as a designer, coordinator and enabler of otherwise autonomous activities and where operation management is seen as organising things rather than planning or scheduling them (op. cit., p. 379). Within this model, there is no attempt to establish a direct causal chain from the goals to detailed prescriptions for operational activity. Instead:

"*Attention is paid to structuring the physical, political and cultural setting of action in recognition that purposeful action is an interaction between intelligent agents and structured environments rather than just an information process*" (Johnston and Brennan 1996, p. 379).

The world as such consists largely of conscious and reflective humans with their own purposes (op. cit., p. 378). From this point of view, to attain workflow by linking workers together instead of controlling them, will necessarily imply a great deal of interaction also in the planning process. Besides, individual purposes serving either physical, political, cultural or other interests must make production planning and control a process of negotiation. Maybe especially so when decision functions are being changed, i.e. the way LPS lets the requirements from the foremen or squad leaders in production become commitments to the rest of the organisation. Production planning and control being exposed to negotiation is moreover one of the topics in an article by Stoop and Wiers (1996) that focuses on the complexity of scheduling in practice. The authors point out that, in practice, the different organisational levels of production planning and control often go to work with different and possibly conflicting performance goals:

"*…a well-known conflict between performance measures is the trade-off between utilisation level and order flow time. Such a conflict can occur between the scheduler and the shop-floor manager. The scheduler is generally responsible for delivery reliability, while the shop-floor generally is responsible for the throughput and the capacity utilisation of the shop. These two goals are clearly in contrast with each other*" (Stoop and Wiers 1996, p. 48).

Stoop and Wiers' puzzle (1996) is otherwise with the specific strengths and weaknesses of human cognition, which they claim to be often underemphasised when implementing scheduling techniques (op. cit., p. 37). In discussing the limited cognitive abilities, the authors pay attention to the short-term and long-term memory of humans. Far more interesting from a point of view of the human factors involved in production planning and control, is their outlining of the advanced cognitive abilities making humans superior in scheduling techniques to information systems, with respect to *flexibility*, *adaptability* and *learning* (humans' ability to cope with many stated, non-stated, incomplete, erroneous and outdated goals and constraints), *communication* and *negotiation* (humans' ability to communicate and negotiate with each other, for example if jobs are delayed or if materials are not available as planned), and *intuition* (humans' ability to fill in the blanks of missing information required to schedule, by the use of "tacit knowledge" (McKay et al. 1989: Stoop and Wiers 1996, p. 45). Stoop and Wiers conclude that it is the interaction between techniques and humans that enables the human scheduler to handle the complexity of scheduling in practice.

Accordingly, production planning and control is much about establishing the right balance between techniques and human factors and, not least, about ways of doing it. In a paper on managing project transformation in a complex context, Holmquist (2007) points out that starting transformation from commitment rather than from a rationalistic decision processes is difficult, because consistencies make it possible to choose among several alternatives (Brunsson 1985, Holmquist 2007, p. 47).

Holmquist states that this requires the members of the project community to embrace the view of organisational learning as an activity of communication between interdependent people (Stacey 2003, Holmquist 2007, p. 47). Furthermore, it is the interaction in a project around tensions caused by uncertainty that creates openings towards collective learning (Elkjaer 2005, Holmquist 2007, p. 47). As important parts of this interaction, Holmquist (2007) stresses a process-oriented strategy, a creative climate, formative evaluation and systematic reflections (p. 50-51). His line of argument resembles that of continuous improvement (company level), or *collaborative improvement* (inter-company level), as a consolidated concept in managerial theory and practice, that concerns the planned, organised and systematic process of ongoing, incremental change of existing work practices aimed at improving company or the collaboration's overall performance (Middel et al. 2006, p. 338). When transferring the concept of collaborative improvement to the process of making use of the Last Planner system, one may say that finding the right balance between techniques and human factors needs to be sought by ways of promoting joint knowledge, not only about the system itself and how it works, but also about what doesn't work, why, and how to move on.

The outset for the case study was thus an understanding seeing LPS as a general approach to the management of complex projects, a feeling being supported by Bertelsen and Nielsen (1999) reporting a similar approach emerging in an effort in the early 1990'ies to introduce just-in-time supply of building materials, where it worked as well. In the shipbuilding case analyzed in this paper the LPS also worked very well. Due to the competition within the industry, specific data are hard to get, but the shipyard reports that 2007 was their best year ever with a profit of almost ten percent and a timely hand over of all the vessels. They do not – because of the competition – state explicitly that LPS was a main reason for this, but indicators such as the speed of throughput signals that LPS was a key factor.

METHODS

The empirical data were obtained from accomplishing action research into one shipyard and its process of making use of the Last Planner System. Action research implies that the researcher, in collaboration with the groups studied, uses the outcome of the research as a basis for concrete actions with an aim to improve the problematic relations uncovered. The researcher often participates in the formulation of actions to be taken, where experiences from these actions typically make way for new research investigations, and in turn new actions (Grönmo 2004, p. 12). Change is thus an intrinsic part of action research, which by no means makes the researcher the driving force behind it. Rather, what characterises action research is that the individuals who experience a problematic situation are pulled into a critical examination of the problem (Bö and Helle 2002).

Table 1 shows main research activities and methods used for the case study.

Table 1: Research activities, methods and data sources

Research activities	Topic	Data sources
1.Mapping	- Organisational challenges	-Interviews, strategy documents
2.Meetings, Change group	- Effective project accomplishment	-Discussions, introduction (Last Planner)
3.Evaluation	- Last Planner	-Interviews, plan documents
4. Foreman seminar	- Introduction (Last Planner), presentation (evaluation), discussions/group work (improvements)	Discussions, workshops

The case study started up with a mapping of the shipyard's organisational challenges. The mapping was initiated as part of an internal development strategy focusing on effective project accomplishment. It involved informal personal interviews with a small group of key personnel selected on the basis of their function (project management/line management), professional background (engineering, economics, and operational management) and discipline (design, purchase, planning, and production). Results from the mapping were collected in an internal report, in which some of the different challenges that came up during the interviews were presented and discussed. The report also included a list of suggested areas and certain tools to focus on in the following strategy process; one of these concerned the area of production planning and control and use of the LPS. A number of meetings with a small group of people (6-8 persons) finalised the mapping and the subsequent report. The group was soon to constitute what was named the "change group". As the name indicates the change group, consisting of a leader and a selected, diversely compounded group of co-workers (besides the research representative), became the main driver behind the subsequent change process. As part of their preliminary meetings an introduction to LPS from a research point of view was provided. The group decided to go further with the system, which initiated discussions about how to adapt it to shipbuilding production and to the shipyard's way of organising its projects. In this discussion some important adjustments to the organization, commented upon in the analysis to follow, were made. For the trying out of LPS, one ship and its docking and fitting out phases was chosen as pilot project and the project manager was nominated responsible for explaining LPS to the project team and to implement it (A discussion of main the case from an engineering point of view is given in Dugnas and Oterhals. 2008). Halfway into the project an evaluation was accomplished by informal interviews (personal and by groups) of almost all the foremen in production, focusing on what worked and what didn't in the new system and how to improve the working of it. The results were presented and discussed at an internal foreman seminar organised by the change group, where management representatives also took part. The seminar led to the identification of a number of possible improvements, and to the initiation of several new development projects as well as the implementation of LPS in the same phases for all new vessels.

APPLYING LAST PLANNER TO SHIPBUILDING PRODUCTION – A PROCESS-ORIENTED APPROACH

Table 2 outlines a process-oriented approach to applying LPS to complex project production. It suggests collaborative improvement based on adaptation, formative evaluation and systematic reflection through seven steps of investigation, where each step has some main activities and a potential collective learning as the outcome.

Table 2: Process-oriented approach to applying Last Planner

Collaborative Improvement	Seven steps of investigation	Main activities	Collaborative learning
Adaptation	1. Problem definition 2. Anchoring 3. System development	- Investigating the problem, identifying alternative actions and goals - Addressing the main drivers of change - Developing a system applicable to shipbuilding production	- Understanding what kind of production shipbuilding is - Realizing the value of commitment and negotiation - Grasping the principles behind the new system, as well as its procedures
Formative evaluation	4. Testing 5. Goal achievement	- Introducing the new system - Measuring results obtained in proportion to fixed goals	- Experiencing its workability in practice - Apprehending the pros and cons of the change process, identifying new areas of effort
Systematic reflection	6. Networking 7. Research	- Exchanging of knowledge across companies and industries - Analysing, in more detail, the root causes of particular problems, developing new tools	- Developing useful, usable knowledge about methods, tools and techniques - Gaining a deeper understanding of social conditions at work

Collaborative improvement

Collaborative literally means working together. Collaborative improvement is, in its original form a concept used to address a purposeful inter-company process that focuses on continuous incremental innovation aimed at enhancing the collaboration's overall performance (Kaltoft et al. 2006, p.

348). In this paper, collaborative improvement is first and foremost used to describe the collaboration between the different production units within the shipyard. However, although most units are employed by the shipyard, they represent various trades, with each trade having its own interests and practices depending on what they do and where they are placed in the so-called parade of trades (Tommelein and Howell 1998) or rather the parades of trades, because the process includes several parades, very different in their nature (Bertelsen et al 2007). For example, workers dealing with steel outfitting are performing work all over the ship, whereas workers dealing with machinery can concentrate most of their work abaft in the ship. But all processes are fed by a number of flows, which also may be seen as Parades, and one – and only one – of these comprises the Critical Flow (Bertelsen et al. 2007).

While all trades presumably have an interest in improved workflow, the degree of interaction related to the kind of work one does will most likely affect total precautions in so doing. Furthermore, while some trades (like machinery) rely heavily on suppliers of critical components, other trades (like painting) are more or less easily supplied. Delays in delivery of material and components, which is one of the most frequent reasons for interrupting the workflow and causing delay, will therefore strike certain trades more than others. The overall point about collaborative improvement is that despite a shared interest in improving the workflow, collaboration with an aim to do so, will necessarily have to handle several disagreements and conflicting point of views about how to attain it.

Adaptation

Organisational or collective learning literature often makes a distinction between adaptation and innovation (Ellström 2001). Whereas changes occurring within a given framework tend to be recognised as adaptations, innovations imply breaks that go beyond the given and therefore represent something creative or new (Holmquist 2007, p. 47). The Last Planner System is already developed and well tested within construction. When this is said, to make LPS fit the shipbuilding process, some important local adjustments were made. In addition, for the shipyard in study to make use of the system involved a new hierarchical level of decision, a change in decision functions, and a shift in focus regarding production control. Thus, although adaptive by corresponding to practices as part of a well-developed tool, creative learning was enhanced all the way from the beginning through stimulation and organisation for joint critical reflection. As a result of such early reflections, it was decided that weekly work plans and look-ahead plans – as well as their related plan meetings – should be divided into to three parts of the ship: Afterbody, forebody and superstructure. There were several considerations implied in this decision, most importantly reducing the complexity of the planning task and the number of participants, and at the same time increasing the relevancy of the weekly plan meetings.

To conduct the planning meetings – both the weekly work plan and the look-ahead meetings – a dedicated process manager was nominated to ensure a high level of coordination between plan levels and planning zones. These adjustments may seem in some way self-evident, however they generally grew from discussions between co-workers (in meetings, held by the committed change group) on how the new system could and should work, given the nature and character of a shipbuilding project.

Formative evaluation

In order to benefit from practical experiences one has to actively process and transform them (Kolb 1984, Holmquist 2007, p. 47). The traditional way of doing this is by carrying out an evaluation after a project has ended, in order to be able to learn from one project to the next. Formative evaluation is, by contrast, carried out during the running of a project and aims to support learning, transformation and development within the project (Guba and Lincoln 1989, Holmquist 2007, p. 49).

The formative evaluation conducted as part of this case study opened up several issues for improvement related to the Last Planner System. These may be grouped into three main areas: The problem of interpretation, the problem of coordination, and the problem of cooperation. The problem of interpretation concerns the different meanings attributed to the Last Planner system i.e. regarding the use of some of its principles, in particular the PPC measure. What does PPC actually measure, how is it useful and to whom?

The evaluation uncovered a range of ambiguities in this. As a result, it was decided to arrange for an internal seminar for the superintendents and foremen, where the system was to be further discussed, and where a presentation and evaluation of main findings from the evaluation was to take place. The problem of coordination relates to a somewhat fundamental characteristic, being found in every temporary production system, namely that it is constituted of agents with merely their own objectives. Why adapt to a particular way of performing production planning and control when we have our own considerations? Bertelsen and Sacks (2007) look into this inherent conflict found in almost any temporary production system. For instance, the evaluation showed that the pull-principle of the LPS implied that shop drawings were to be pulled by the production progress. Unfortunately, this finding was not easily transferred to the engineering department and in turn this has led to the initiation of a research mapping, looking into what kind of production engineering is.

The problem of cooperation is deeply rooted in that of coordination, even though it addresses human agency in a more direct way. From the evaluation it was clear that there are social conditions implied in production planning and control, such as trust, communication and openness, which need to be included as parts of the system – not least the functioning of the planning meetings – in order to improve the workflow. At the foreman seminar and at later meetings in the change group, a particular focus has thus been on the human factors involved in production planning and control.

Systematic reflection

In recent years, various practices have been suggested as best practice, assuming that their adoption would lead to higher performance (Laugen and Boer 2007, p. 397). The Last Planner System, as such, has proven an effective tool for improving the productivity of the production units that implement its procedures and techniques (Ballard and Howell 1997, Ballard 2000, p. 5). However, in terms of making use of a new concept some argue that it may not be the concept itself, but the very implementation of it that is essential for success (Bessant and Francis 1999; Savolainen 1999). Held against LPS, this assertion certainly calls for some reflections, amongst others upon: What does LPS actually contribute in terms of improving the workflow? Which techniques seem to work, which do not, and why? Are there problems uncovered as a result of its' utilisation that invoke other solutions? In order to develop usable and robust knowledge about the true effects (and weaknesses) of the methods, tools and techniques implied in LPS, it is here suggested – as part of a process-oriented approach – to make way for networking between companies for the exchange of experiences, and to enhance research for the accumulation of data and reports of its use and results achieved. There are reasons to believe certain LPS procedures are more important than others, as well as there probably are local variations in terms of which procedures seem to work and which do not. Research and networking could help understanding such limitations and variations by paving the road for systematic comparisons between a numbers of cases. In the end, this may support the development of attachments to the Last Planner System to improve its capacity, and it might even lead to the developing of complete new tools or systems for workflow improvements.

CONCLUSIONS

The paper sets out with the objective of understanding the working of Last Planner System in a social perspective and to start an investigation of the generality of the approach to project production. It shows that the Last Planner System of production control can be used in the shipbuilding process, just as a similar system did in a just-in-time supply of building materials experiment (Bertelsen and Nielsen 1997). This indicates that LPS may be a more general approach to project production than recognised or, indeed be an emergent method for production control in any complex, sequential project.

It also suggests that to benefit from making use of the system, collaborative improvement should be included in the transformation process. Collaborative improvement, based on adaptation, formative evaluation and systematic reflection, promotes collective learning. In complex projects with multiple agents collective learning is thought of as decisive to improve total workflow.

Production planning and control is claimed to be about finding the right balance between techniques and human factors. LPS, and especially the look-ahead process as a level of coordination between a master plan and a weekly work plan, represents a valuable contribution. However, it needs to be supplemented by a consideration of the social factors at work. This requires seeing production planning and control as a process of negotiation and communication, where human aptitudes for flexibility, adaptability, learning and, not least, intuition play a major role in applying LPS. This is achieved through a seven steps of problem-driven investigation, managed by a dedicated, action-oriented and at the same time reflective group of people.

This paper's aim has been to explain and describe a process-oriented approach to production planning and control within the shipbuilding industry. There are several problems identified and questions raised in the paper which may be topics for future research. Human or social factors are said to be important for production planning and control, but the paper does not go deeply into how different factors affect which parts of the production planning and control. Thus there is a need for research on the social mechanisms implied in this process. Collaborative improvement actualised from the standpoint of the different production units involved in a shipbuilding project. However, it does not go into the problem of inter-company collaboration to improve the workflow. Research looking at the different courses of action related to this problem, and maybe also providing concrete examples of ways to overcome the various obstacles involved in it, would be of high relevancy. Finally, there is very likely a vast amount of experience gained from many cases of employing Last Planner. Nevertheless, there seems to lack a systematic collection of data and cross-sector analyses. Research with the intention of gathering information across companies, industries, and maybe even nations, would probably be of crucial importance to the further developing of useful and usable knowledge within this particular field. But the work reported raises also the more general question:

We know Last Planner works. But do we understand why?

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