INTEGRATED PLANNING VS. LAST PLANNER SYSTEM

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ABSTRACT

The research question of this paper is whether planning methods with strong characters of traditional approaches may be aligned with the underlying principles of the Last Planner System (LPS).

A Scandinavian building contractor has for many years worked on implementing its translation of LPS combined with CPM, which has proved not to take out all the benefits from LPS. Hence the case company has started to develop a new planning system denoted Integrated Planning, and which can be associated to the ideas from location-based planning and takt planning. The focus of the paper is to evaluate this planning methodology in relation to the principles of LPS.

The paper concludes with the finding that it is possible to combine Integrated Planning with the LPS principles. However, the system is in many ways an expert system, and needs to be further developed to more explicitly include lookahead planning and constraint analysis and the aspect of continuous learning. It is central to make use of simple planning techniques as manual reversed scheduling to compensate for the expert feature.

KEYWORDS

LPS, CPM, traditional planning, production control, integrated planning

INTRODUCTION

The problem of this paper is whether a method, denoted Integrated Planning with strong characters of traditional planning practice, may be adjusted and aligned with the underlying principles of the Last Planner System. How this adaptation should be done is addressed by using the practices that will start to break the previous paradigm.

The Last Planner System (LPS) has been developed since 1992 (Ballard 1993, 2000). Lean Construction Institute (LCI) presents LPS as a production system created to produce predictable work flow and fast learning in programming, projecting, construction, performance documentation and hand over of projects[4]. LCI licenses the use of the processes in LPS to organizations. In Norway it is common that companies provide their own translations of LPS, such as Collaborative Planning (Veidekke and

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[4] Based on an un-dated note downloaded from LCI's home page, 2014.

Kruse Smith), Trimmed Construction (Skanska) and Collaborative Project Execution (Nymo).

The Norwegian building contractor and property developer which is focused upon in this paper has worked on implementing Collaborative planning since June 2008. The most frequently used elements of LPS are start-up meeting with phase planning, meeting structure with different time frames and involvement of suppliers.

The company has, on the other hand, experienced problems in making its version of LPS work as intended, and is developing its production system further. The company is establishing methods, which at first sight, resemble traditional planning. This is done by the use of Gantt-diagrams and software, which is also applicable in the critical path method, and associated with traditional practice. This altered method implies that planning is broken down into manageable and clear units with similarities to a method known as location-based planning and takt planning (Seppänen et al. 2013; Frandson et al. 2013; Linnik et al. 2013; Fiallo and Howell 2012; Kala et al. 2012; Seppänen et al. 2010; Kenley and Seppänen, 2009). This is contrary to traditional planning, which is mostly based on activities and work packages distributed in time, not on location.

The company was certified in accordance with NS-EN ISO 9001:2008 in 2012. The most substantial principles for management in accordance with NS-EN ISO 9001:2008 is focus on the customer, leadership, use of available expertise, process mentality and control of the synergy between processes, continual improvement, fact-based decisions and cooperation with supplier. The use of LPS underpins these principles. Furthermore, the company perceives changed planning methodology as a support of LPS. This was the reason the company wanted to use this methodology.

We can understand LPS as a critique and response to traditional project control and planning. In this paper we want to compare the foundation principles of LPS (Ballard et al. 2010) with the altered method for project management of the company in question. Central to this is to derive what are the central conceptual principles of LPS. Conceptual principles may be understood as normative theory related to best practice. We may, for example, consider facilitating for learning and continuous improvement as a principle, ensured by measuring Percentage Plan Completed (PPC) and perform a factorial analysis on deviations from the plan, which will be discussed with the involved parties on the construction site.

The paper is based on the "Constructive Research"-approach (Kasanen, Lukka and Siitonen, 1993). What is designed or constructed is the case company's planning system, which is expected to provide better control and work flow in the construction process. The verification is done in accordance with the theoretical principles of LPS and in accordance to expected function. The article is first and foremost conceptual and methodology-oriented, and is expected to provide a theoretical contribution to the foundation of LPS and especially to the question of whether more traditional approaches can be adapted to the principles of LPS. There are for instance several references related to localised-based planning and takt time planning related to LPS, e.g. Seppänen et al. (2010).

In the continuation we will firstly explore the distinctive characters of LPS and traditional planning, subsequently we will focus on the foundation principles of LPS and how these differ from traditional production control. Furthermore, the new plan and control system of the company will be presented. The new system which is under development is thereafter analysed in accordance to the principles of LPS.

LAST PLANNER SYSTEM AND TRADITIONAL PRODUCTION CONTROL

In the first development phase of the Last Planner System (LPS) the focus was on improving productivity inspired by the quality management and productivity initiatives which dominated the improvement works in the construction industry in the 1980's (Ballard, 2000). The conceptual framework of LPS was thereafter changed to focus on predictable work flow. The change in conceptual approach is reflected in “the revolution in manufacturing inspired by the Toyota Production System” (Ballard, 2000: 1-6) and the flow part of Koskela's (2000) works on production theory, the so-called TFV-theory (T= Transformation; F= flow; V= value). Productivity measured as input in relation to output can best be associated to transformation, while flow also addresses the processes occurring between the work operations. Work flow is defined by Kim and Ballard (2000) as “the movement of information and materials through a network of production units, each of which processes them before releasing to those downstream”. This may simply be interpreted as predictable hand off of work between disciplines.

Ballard (2000) presents LPS as a system of control, which causes the realisation of plans and which therefore also ensures the manager's responsibility to handle both contract management and production management. Control is further explained as a function which makes activities approach a pre-determined sequence, initiate re-planning when the established sequence is no longer possible or desired, and initiates learning when activities do not coincide with the plan (Ballard, 1998). Production management is planning and control. LPS adds a production control component to what is characterised as a "traditional production management system". LPS may furthermore be understood as a set of four mechanisms to transform what should be done to what can be accomplished (Ballard and Howell 1994). What is traditional production management? Ballard (2000) uses the term "traditional schedule-push system" (pp. 2-15) and argues that this in LPS is supplemented with "pull techniques", and refers to Hopp and Spearman (1996), when it comes to the better performance of "pull", but that "pull" in addition is beneficial to handle situations with variations. Furthermore it is claimed that traditional project control assumes the necessity of central control, and it is argued that a dynamic production system cannot be controlled centrally, but "rather are adaptive creatures driven by decision making in the periphery" (pp. 2-16). Ballard (pp. 10-11) indicates that the participants in his case studies regard LPS to be superior to traditional production control.

Gregory Neil Associates[1] argues that current practice, which we can relate to as traditional planning, separates planning from implementation, and points to the practice of freezing the plan (base line plan) when it is accepted by the builder and project management, but which will soon be of no interest and useless to the executors. It is claimed that this type of main plan does not provide the project management with control, and the author argues that the lean method adds "headlights" to the project, at the point where traditional projects only have "rear

[1] Undated note downloaded from Lean Construction Institute’s home page

lights", with fact reporting at the end of the month. Mossman (2012) characterises traditional production control as "the old way", in which he includes "Critical Path" (CPM) push planning, Command and control organization; Adversarial and transactional commercial terms". Mossman does not elaborate all of his claims, but writes that the critical path method pushes work in to the production based on a pre-determined start and stop without taking due consideration to whether the work is ready to be completed.

The critical path method is related to the widespread method where plans are visualised as a beam chart, often wrongly called a Gantt chart (Weaver, 2013)[1], where start and stop-dates are calculated for activities/work packages when sequences, duration and dependability between activities are coded in addition to milestones established. Critical path may then be calculated as the sequence of activities which will delay the entire project if delays occur in individual activities on the critical line, if no mitigating measures are employed (Kelly and Walker 1959).

TRADITIONAL PRODUCTION MANAGEMENT AND UNDERLYING PRINCIPLES OF LPS

Ballard, et al. (2010) derive five principles from the LPS, which are 1) plan in greater detail as you get closer to doing the work; 2) produce plan collaboratively with those who will do the work; 3) reveal and remove constraints on planned tasks as a team; 4) make and secure reliable promises; and 5) learn from breakdowns. This is changed somewhat in an ongoing work, where Kalsaas (2014) lists the following six underlying conceptual principles of LPS:

1. Increasing degree of detailing and decentralised control towards completion (non-deductive perspective)
2. Involvement across subcontractors and disciplines
3. Involvement of all employees, including the individual worker ("The last planner")
4. Emphasize continuous improvement and learning
5. Employ the pull principle as the foundation for production control.
6. Simple and manual planning technique.

The first principle is connected to that we in LPS continually work on realizing the plan as previously described, and that the planning system is decentralised by the executing parties participating in decision-making on different levels, in order to realise the plan through removing constraints which may hinder the implementation of a plan. This means in practice that the expert planner becomes more of a process manager to make necessary decisions and clarifications on different levels.

Principles 2 and 3 are reflected in the planning and control tools of LPS: Master plan: Phase plan developed using reversed scheduling technique; Lookahead plan;

[1] We however use the term Gantt-diagram or chart in this paper, as it most likely communicates best.

Weekly plan; Team plan[1]; calculation of PPE (Percentage Planned Executed) and causal analysis of variance. The team plan is a plan for the individual worker ("the last planner"). The phase plan is prepared across subcontractors and disciplines, and identifies milestones and order of activities and work packs. The Lookahead and the weekly plan focus on removing constraints to the realisation of the plan. Both planning tools are interdisciplinary.

Continuous improvement is concretised in LPS' focus on PPE as well as causal analysis and feedback from experience while the project is on-going. The pull principle at a superior level is in the reverse scheduling technique utilized in phase planning. In the LC-community the clarification of activities towards execution by removing constraints is thought of as a pull-mechanism.

The principle of simple and manual planning technique can relate to the points on horizontal and vertical involvement, but it is considered such an important foundation for involvement that it is kept as a point on its own. We consider LPS as a response and critique to traditional production control, and have performed a comparison to highlight differences, as shown in the table below:

Table 1: Comparison of Principles of LPS and Traditional Project Management

LPS	Traditional
Non-deductive: Decentralised decisions to remove constraints and realize the plan. Continuous control.	Deductive: Centralised master plan without systematic focus on removing constraints. Control afterwards
Horizontal involvement	Limited involvement. Expert planning
Vertical involvement	Limited involvement. Expert planning
Continuous improvement through continuous learning, measuring of PPC, casual analysis and sharing of experience	Monthly reports, e.g. on earned value. Lesson learned after completion of projects
Pull based project control through reversed scheduling and removal of constraints towards construction	Centralized critical path method in planning and pushing the work towards downstream activities
Simple and manual planning technique	Computer based expert planning

In traditional planning the plan documents are often long, and it is both hard and resource-draining to locate the status of a plan. In an example from the construction

[1] Team plan is not part of Glenn Ballard's version of LPS, which is under continuous development. In Norway big contractors, like Veidekke and Kruse Smith use Squad plans. In Glenn Ballard's doctoral degree from 2000 the squad leader is «the last planner».

of an office building for an oil company in the Oslo area the plan was 17 pages long, and consisted of Gantt charts. This mirrors the traditional practice of a fragmented planning and control system, where we often find a detailed main plan/master plan and weekly plans with a weak connection to the master plan (Kalsaas, Skaar and Thorstensen, 2009, 2010), and separate plans for delivery of drawings and procurement. These often lack consistency. The plans for subcontractors and individual disciplines in a traditional, detailed master plan are often at different levels, with uncertainty tied to whether all the various executing companies have covered all their activities in the plan, in accordance with the demand specification. It is furthermore common in the traditional approach that the end-phase sees an increase in staffing to handle the deadline. Degree of completion, and not used resources in relation to planned use of resources, is reported at status reporting. This often provides an untrue image of the situation. The reporting of a higher degree of completion than what is true is common. A contributor to over-progressing is failure to consider the additional labour hours required to perform tasks out of sequence. Doing work out of sequence is motivated by the earned value system (Kim and Ballard 2000), which gives no value to sequence, and other compensation mechanisms that reward progress without regard to penalties for doing work out of sequence.

THE INSPIRED PRODUCTION MANAGEMENT OF THE COMPANY IN THE CASE STUDY

The case contractor focused on in this paper has, after the adoption of the methodology of LPS, struggled finding an effective method and tool for the practical implementation and production control. In the planning phase the sequence of activities/work packages has been decided in a collaborative process with the different subcontractors and disciplines. However, on that basis the management in the different construction projects has created a traditional Gantt plan with the critical path method. This has reaped off many of the benefits to be expected from LPS.

THE CASE COMPANY'S FIRST VERSION OF LPS' INSPIRED PRODUCTION MANAGEMENT

The most frequently used elements of LPS by the case company are start-up meeting with phase planning, meeting structure with various time frames, involvement of subcontractors and the use of different types of planning tools with milestones (detailed master plan, phase plan, lookahead plan and weekly work plan).

The first challenge in the approach for the contractor has been that the phase planning in a project has often been too comprehensive and too detailed. The phase plan has become an operative plan instead of a strategic plan. The plan has not been broken down into manageable units, and because of that is has not served as a framework for the squad leaders' weekly work plan. Instead of taking a physical extract of the phase plan and the lookahead plan in relation to this, the lookahead plan has been created independent of the phase plan, and frequently the consistency between the phase plan and the lookahead plan has been lost. It has furthermore been a challenge that the lookahead meeting has been very comprehensive and detailed as it often deals with all activities in a 6-8 week perspective, without these being structured as to where and in what phase these are in. In the end the experience is that the weekly planning is often implemented for each discipline separately and that the area or phase is not the foundation of the coordination. This leads to a situation where the interface between the disciplines are not discovered and coordinated. To improve the situation the contractor has decided to implement the system addressed below, denoted Integrated Planning. See also the work by Hamzeh et al. (2009, 2011) and Hamzeh and Aridi (2013) which include recommendations for performing constraints analysis in lookahead planning, and Ballard and Howell (2003) who proposes a terminology for task breakdown.

INTEGRATED PLANNING AND PRODUCTION MANAGEMENT

Integrated planning is based on systematising the planning work by involving all parties. The goal of this is to be able to plan, coordinate and measure the progress of the project. Figure 1 illustrates an overview of the planning types involved. The master plan is a traditional milestone plan which sets the framework of a project. Thereafter projects are divided into zones and phases. The zones serve as control areas. So do the phases, which in addition provide rhythm to the projects. The production plan is a location-based plan at a slightly superior level. When the production plan is detailed with activities we have a work plan. Thereafter the system includes follow-up, or production control and routines for reporting.

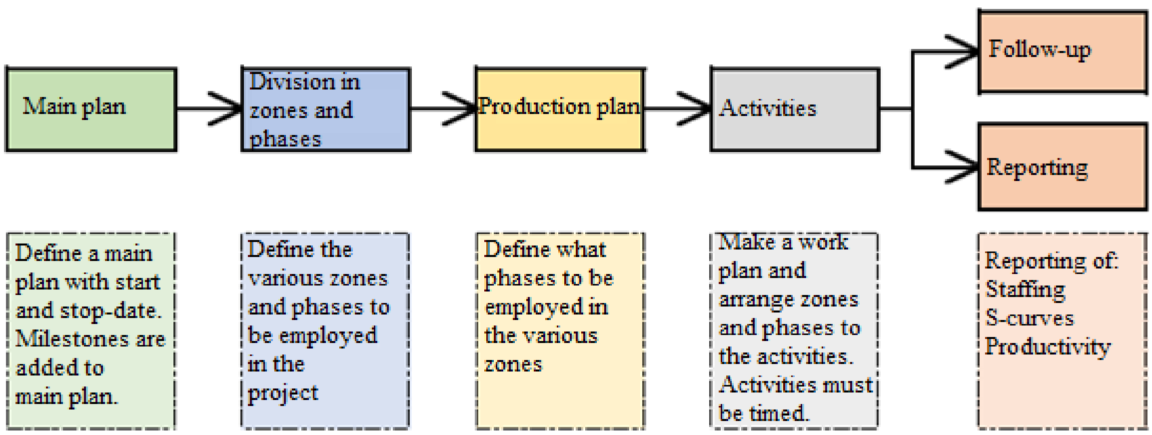

Figure 1: Overview of the Integrated Planning concept

A main plan must be created from the project description. This has to be done early in the project phase, inverted and be quality assured by project participants and customer. The main plan may be established by the use of a superior visual presentation which has its basis in the planned start and stop dates of the project, including a distribution of main activities and milestones. This may be done in a spread sheet, as illustrated in Figure 2.

Distribution of the physical project scope into zones and the sequence of the actual project completion in phases must be done in cooperation with all actors, meaning all disciplines and subcontractors should be involved. The distribution is important for project control in limited areas. All projects are distributed in geographical or physical zones. We often find a natural distribution in relation to building, wings, floors, special rooms and so forth. There is some experience with regard to "size" on, and number of, zones, but it is hard to generalise. One rule may be a physical divider, like a floor or larger room. The zones in the project must include the entire physical work scope, and may for example be: Building A, B, C - Floor 01, 02, 03. - Outside, Technical room, Basement, Shafts, Roof.

Within zones containing multiple disciplines the project is divided into phases. This is the rhythm (phases) of the project, and may be divided into for example: Thin wall screeding, Inner walls and Hidden installations, Paint, Tiles and Ceiling, Completion, Testing and Final inspection. The duration of the zone is a product of duration of phases, and must be considered separately in each zone.

A production plan works as a superior map of the entire production, and is generated from the connection between zones and phases on a time scale as illustrated in Figure 2. This is a location-based plan, and the most important is that it provides a clear image of the project as a whole. This plan should be established early in the process, before activities and work packages are decided and included. It is important that all involved parties make this plan jointly. For best possible overview and flexibility it should be created in a simple system, like a spreadsheet. Figure 2 illustrates an example of how phases and zones form a production plan when coded together.

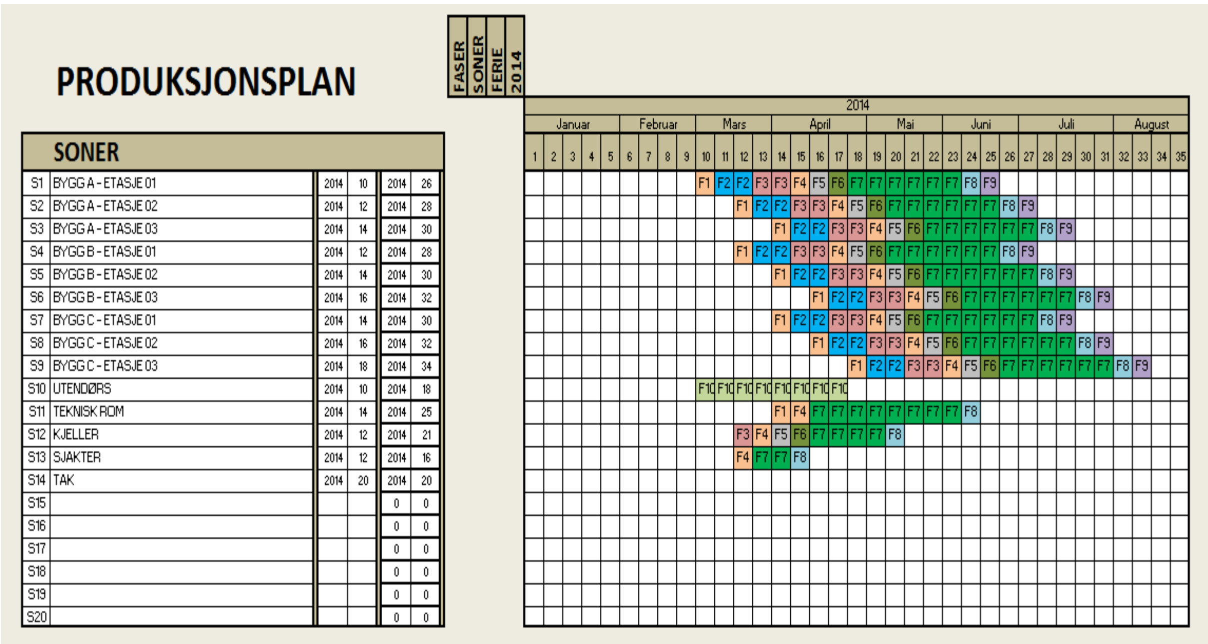

Figure 2: Location-based production plan

The location-based production plan is a highly important part of Integrated Planning, in order to distribute teams between zones and to plan the number of staff. The phases in a project have a determined sequence, or series, while work in zones happen in parallel, and seldom, or never in series. One example may shed more light in this. If we have 10 disciplines where each has a throughput time of 2 weeks, the project should be completed in a series of 20 weeks based on one team for every discipline. However, such an organisation easily leads to several stops in the production, poor work flow and poor exploitation of resources. If the project was carried out as a thought experiment with full parallelism between the disciplines, the project could be completed in 2 weeks using 10 teams. To what degree the utilization of parallelism is utilized is controlled by the amount of time at disposal within each discipline and zone and not least the overall duration of the project. The key to good utilization of resources and staff is in aiming that the same team as far as possible move from zone to zone. This demands planning to apply time shift between the zones. The division of teams between zones is furthermore the key to making activities sound in the LPS-terminology with respect to there being space to perform the work for teams from different disciplines. We achieve what is known in takt planning as a production train (Frandson et al. 2013; Linnik et al. 2013; Fiallo and Howell 2012).

In order to follow up each discipline the production plan must be detailed with activities. This must be done by each discipline, and inserted into a common system. It is important that no activities go across zones and phases, and that the sum of all activities is mirroring the entire work scope of each and every discipline, and the entire project. Every activity must also be given a name which is precise and understandable, and which must be coded in relation to: Zone, Phase, Discipline, Resource (man hours or cost). In order to measure other than front line, and to be able to consider the resource distribution within both discipline and phase, the activities must be allocated resources. The sequence of the activities is best decided by the various squad leaders involved in the project by using principles connected to LPS.

When activities are allocated resources, coded to discipline, phase and zone, the plan is considered finished, and one may extract the information needed. By actively using the plan together with the various disciplines in the project, one may update and measure the progress continuously as the project progresses. It is also easy to intercept changes, and implement these. In the spreadsheet, where activities are tied to zone and phase, one can extract data for lookahead plans by selecting activities based on zone and time.

Updates and measuring of progress may be done using software programme able to handle Gantt diagrams based on imports from spreadsheets. All activities are added to the programme and coded in relation to discipline, zone and phase, and they are also allocated resources. By grouping and filtering in the programme one can, in addition to the entire project, reveal those areas or disciplines one wants to update or monitor. The programme can also be used to generate numerical data for s-curves and staffing histograms. The actual reporting is done in the planning program, while the managing of numbers is done in a spreadsheet. Updating of progress can be marked by a colour for each activity, or activities may be followed-up by using a planning program. If all activities are coded in relation to discipline, zone and phase, and updated, the users may simply discover if the work is behind the current plan.

COMPARISON OF INTEGRATED PLANNING AND LPS

One main challenge for the implementation of Collaborative Planning with the case contractor focused on in this paper until now, seems to be that the project managers to a high degree have continued to use the traditional planning methods with Gantt planning and the critical path method by coding activities and calculating start and stop dates based on coded dependencies etc. This has occurred while elements of LPS have been implemented. This is not the main focus of this paper, but there should be no reason to be surprised that this mix is experienced as problematic in achieving increased predictability in the work flow. Experience with multidisciplinary and involving phase plan-meetings with the use of post-it notes is experienced as a huge improvement, however reversed scheduling has not been used as a method, and there has not been any systematic work in making activities sound for completion. Thus, the practice is quite far from the LPS-principle of pull planning.

The concept of Integrated Planning is thought to replace traditional planning which is part of the first phase of Collaborative Planning in the case company. The question is then if and how Integrated Planning can be combined with the six identified principles of LPS, which are discussed above. Table 1 display comments about the properties of Integrated planning concept in relation to LPS.

Table 1: Integrated planning and LPS

Integrated Planning and Project Management	Comments in relation to LPS
Master plan: Strategic plan where the main frames are frozen. Milestones are input to all other plans.	Similar to LPS
Division into zones: This means dividing the project into physical units which serve as control areas. Performed early so that the design can be adapted to the zones.	Establishing of zones/control areas are also used in LPS by the use of location-based planning, also known as line of balance.
Division into phases: The project is divided into phases. While it is planned to work parallel in zones the phases are sequential. Start and stop for each phase make up a milestone.	The duration of the phases can be established by reversed scheduling at a phase level in collaborative planning, as in LPS.
Duration in zones is a product of the duration of the phases: Decided in collaboration with the different subcontractors and disciplines.	In accordance with location-based planning.
Location-based production plan: Operative plan which provides an overview of what phase to be worked on in the various zones. The throughput time of work and the work load of the project decide to what degree the teams must work in parallel. Important foundation for resource planning.	In accordance with location-based planning. Hard to see that this may be used as a lookahead plan without considerable adjustments. The level of detail seems to be too coarse.
Production plan at activity level: The subcontractors and disciplines detail the work in the various zones and phases. The result is a multidisciplinary work plan. This provides a foundation for the creation of plans for the various teams.	This corresponds to a weekly work plan in LPS. It is assumed that it is possible to expand the concept of constraint analysis related to the seven flows and to consider the soundness of activities and work packages.
Production control: Measuring status to be able to perform a causal analysis and make corrective and preventative actions is central to the concept.	This may be in line with LPS if the basic philosophy behind LPS as production control is assumed (principle 1).

Integrated planning is in many ways an expert system, and it is developed on bases of a combined use of spreadsheets and an industry standard Gantt planning software. Coding of dependencies between activities is however not utilized. Thus the method is not based on the critical path method with calculation of start and stop of activities. The method makes use of location-based planning which is not new to the lean construction research community as documented above.

The developing company strongly emphasizes that Integrated Planning will make it simpler for the actors on the construction site at any time to identify the status in the plan, and to have a useable tool for tracking productivity, cost and progress, e.g. earned value. LPS does not have this tracking functionality, because when LPS was developed, it was assumed that methods for tracking productivity, cost and progress were already in place (Ballard 2000). This was true for the companies in the industrial sector from which Last Planner emerged. The main contractors in Norway also apply these economic management tools in combination with their translations of LPS.

CONCLUSION

The Integrated planning system documented in the paper has location-based planning as a central element. It has properties which make it usable as an expert-system, but if the user organization makes the correct facilitations it may also be used in accordance with the principles of LPS. The hardest principle to satisfy is simple and manual planning technique. To overcome this there should be adopted more manual and interactive techniques which are outside of the current version of Integrated planning. The system should be further developed so that it can accommodate more explicit removal of constraints at the lookahead and work plan-level, and develop a procedure for the preparation of PPC (Percentage Plan Completed) and causal analysis of deviations, which is highly central to learning and continuous improvement.

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