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WHAT IS A GOOD PLAN?

Trond Bølviken[1], Sigmund Aslesen[2], and Lauri Koskela[3]

ABSTRACT

The word plan is in English both a verb and a noun, reminding us that *to plan* is a process resulting in a product, *a plan*. While the Last Planner System (LPS) is primarily focused on how *to plan* and control production, other planning concepts are more focused on the plan contents (*the plan*). A more explicit approach to the characteristics of a good plan could improve LPS as a planning concept. The paper proposes such a list, based on a discussion of the plan contents highlighted by the following planning concepts: Critical Path, the Location-Based Management System, Takt Planning, Critical Chain, Agile, Task Planning and the Last Planner System.

KEYWORDS

Last Planner System, Scheduling, Plan Quality.

INTRODUCTION

While Dwight D. Eisenhower (1957) said that "Plans are worthless, but planning is everything", the present paper is based on the view that "planning is everything, but plans are also something". While the Last Planner System[4] (LPS) has its main focus on the planning process (how *to plan*), many of the other planning concepts identified and discussed in this paper have their main focus on the result of the planning process, *the plan*. We have within Lean Construction over some years seen an increasing interest in some of these planning concepts[5]. This interest can be understood as an interest for the plan contents in addition to the planning process of LPS. The present paper proposes a set of criteria for a good plan. The hope is that these set of criteria can be used to improve LPS as a planning concept.

METHOD

The method used is theoretical reasoning based on authoritative sources. We have identified seven planning concepts relevant to our topic. First we give a short presentation of each concept and identify the main plan contents highlighted.

[1] Director of Strategy, HR and HSE, Veidekke Entreprenør AS, P.O. Box 506 Skøyen, N-0214 Oslo, trond.bolviken@veidekke.no

[2] Development manager, Veidekke Entreprenør AS, P.O. Box 506 Skøyen, N-0214 Oslo, sigmund.aslesen@veidekke.no

[3] Professor of Construction and Project Management, School of Art, Design and Architecture, University of Huddersfield, Queensgate, Huddersfield, HD1 3DH, United Kingdom; email l.koskela@hud.ac.uk. Also at Department of Civil and Structural Engineering, School of Engineering, Aalto University.

[4] The Last Planner is a registered trademark of the Lean Construction Institute.

[5] We will in the paper use the terms *planning* and *scheduling* as synonyms.

Secondly we establish the structure of our proposed list, before we discuss some topics related to the contents of the list. Finally we conclude by proposing the list.

PLAN CONTENTS IN THE IDENTIFIED CONSEPTS

CRITICAL PATH METHOD (CPM)

CPM was first presented by Kelley and Walker (1959) and has later been developed in several variants (Kenley and Seppänen, 2010)[6]. As the name indicates, a main approach of CPM is to find, calculate and optimize the critical path of the project. The critical path is the sequence of activities (path) that has the longest duration and therefore is determining the total duration of the project. In order to establish and calculate the critical path, the plan must consist of activities with two fundamental features: Dependencies and durations. The duration of an activity can be determined by technical properties, (e. g. the time it takes for concrete to cure), but the main issue will usually be that the duration will be dependent upon the amount of manning resources allocated to the activity. Because there will be strong limitations to the flexibility of the manning of the project, CPM is therefore also focused on resource levelling. Different levels of resources result in different durations of tasks resulting in different critical paths through the project.

The dependencies between activities can be determined unambiguously by technical dependencies (e. g. the excavation for a building has to be done before one can start constructing the basement) or they have to be determined through the planning process[7]. Visually a CPM plan is usually shown as a Gantt diagram, focusing on the durations, or as a network diagram focusing on the dependencies.

Summing up, CPM is specially focusing on the following plan content:

1. The work breakdown structure, that is the tasks that will be the unit in the planning
2. The dependencies between tasks
3. Reliable estimates of the durations of each task
4. A optimal level of resources
5. The optimal project duration

THE LOCATION-BASED MANAGEMENT SYSTEM (LBMS)

As indicated by the name, LBMS (Kenley and Seppänen, 2010) is basically focused on the location where an activity / work package is to be carried out. The goal is to make a plan where only one activity at a time is carried out in each location (zone) and where resources can move from one location to another without waiting. In construction, production is done by resources moving through the product instead of (as in manufacturing) the product moving through production. LBMS is therefore a

[6] There is a large amount of literature on CPM. Over 40 reference books are used at universities in the USA (Galloway, 2005). Good presentations of CPM are given in among others (Sears, Sears and Clough, 2008) and (Kenley and Seppänen, 2010), chapter 2.

[7] Example: Two activities A and B are to be done in the same area. They can for practical reasons not be done simultaneously, but A could be done before B and B could be done before A.

planning system designed especially for the type of production we find in construction (and shipbuilding).

Graphically a LBMS schedule typically uses flowline (Kenley and Seppänen, 2010, pp. 71), a two dimensional diagram with locations on one axis and time on the other. A good plan is a plan where the lines indicating each trade are continuous (indicating flow of work), not crossing (indicating only one trade at a time in each zone) and with an optimal distance (indicating time buffers).

Summing up, we find that LBMS is specially focusing on the following issues:

1. The different zones where the work is to be done
2. One trade at a time in each zone
3. The trades having continuous work

TAKT PLANNING

As indicated by the name, Takt Planning[8] is focused on establishing a fixed takt in production. Takt Planning is a concept coming from the assembly line in manufacturing, where the takt is the time the intermediate product is at any work station before moving to the next. At the assembly line the takt is a physical reality, the line is moving at a specific speed and all work stations have to comply with this. Not so in construction. Because in construction work is moving through the product, the takt (if there is to be a takt) has to be established by the plan. This is done by dividing the object (e. g. the building or road) into zones and deciding a construction direction in which work is to move. The construction direction is to be established in a way that prevents transportation through zones that can be harmed by such transport or where the transportation can come in conflict with ongoing work, does not mix or intersect ingoing and outgoing material flows, and minimizes the transportation from zone to zone.

The takt time cannot be set shorter than what is allowed by the bottleneck activity (Seppänen, 2014), and sets a common upper-bound on the time anyone trade is afforded to use in any one zone. The plan establishes a push mechanism where all work packages are to be executed at the time and location determined by the takt plan. Due to variability, the trades will have to plan with a certain amount of buffers. If production is lagging behind the plan, the trades will have to work more hours a day than planned or have access to extra workers. (These workers will for obvious reasons have to come from a production process that is not takted.) If the trade is working faster than scheduled, they will either have to reduce their crew size, be idle or have access to a backlog of task. (This backlog will also have to be part of a production that is not takted.) By the end of each takt (time slot) there will be a hand over of every one zone from one trade to the next. The hand over should confirm that all work is done and with the right quality.

Summing up, we find that Takt Planning is specially focusing on:

1. A specific construction direction

[8] We have not found any single in depth presentation of Takt Planning, but have in our work with the paper used Frandson, Berghede and Tommelein (2013), Porsche Consulting (in Press) and Seppänen (2014) as references. Two of the authors have attended a training course in Takt Planning at the Porsche Akademie in 2011.

2. The division of the building (or whatever object is to be constructed) in zones of approximately the same size
3. One trade at a time in any one zone
4. The work to be done within time slots of the same duration
5. Hand over between trades with control of completeness and quality
6. Buffers of tasks and resources

CRITICAL CHAIN (CC)

The motivation of the development of the Critical Chain (Goldratt, 1997) has been in certain shortcomings of CPM, although also many features are inherited from it (Koskela, Stratton and Koskenvesa, 2010). In contrast to CPM, CC acknowledges that there is a need to respond dynamically to uncertain durations. In CPM, the task durations contain buffers to accommodate variation. These buffers inflate the total duration. In CC, the central idea is to explicate these buffers, to situate them strategically and to manage them actively for shortening the duration and expediting the project. This also implies that in a CC master plan, there are no firm task start and end dates. Further, a central idea is that there is effectively only one activity consuming the project buffer at any time – the bottleneck. The assumption is that an improved visibility of buffer consumption creates awareness and opportunity to support the resource concerned and to escalate action when buffer consumption threatens delivery. To make this possible, a frequent reporting, preferably on a daily basis, of projected time to complete the tasks underway is needed.

Summing up, we find that the CC is characterized by the following:

1. Preparation of a master plan that is not assumed to be realized as such
2. Active management of time buffers
3. Frequent reporting of projected task completions
4. Identification of the bottleneck and focusing on supporting and expediting it

AGILE

Agile methods rely on incremental, iterative development cycles in order to complete projects. The aim is to enable adaptation of continuous changes in the development process by adding higher level of flexibility than what is possible with traditional project planning methodologies. Agile methods, such as Scrum[9], are used on projects with a substantial amount of uncertainty in both requirements and technology (Scwaber and Beedle, 2002), e. g. software projects. Scrum deviates starkly from the conventional project management doctrine. There is no work breakdown structure and the dispatching of decisions is totally decentralized (Koskela and Howell, 2002). There is no central representation of action in Scrum. Instead, action follows essentially from the situation, created through prior action and coordination takes place directly among the team members. Feedback cycles are created both on the daily and monthly level (Koskela and Howell, 2002).

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[9] The use of the term Scrum is inspired by an analogy put forth by Takeuchi & Nonaka (1986), who compared high-performing, cross-functional teams with the Rugby scrum formation where each team's eight forwards bind together and try to push the opposition eight backwards in order to gain position.

Summing up, we find that Agile is characterized by the following:

1. Incremental, iterative development cycles
2. No work breakdown structure
3. Totally decentralized decision-making and no central representation of action

TASK PLANNING (TP)

While the present paper and the planning approaches described above basically are focused on time scheduling, TP (Junnonen and Seppänen, 2004) has a broader and more holistic approach. In TP the tasks / work packages are planned in detail and considered from six angles: Analyzing potential problems, scheduling, costs, quality requirements and quality assurance, the prerequisites for the task, and ensuring the progress of the task. TP is related to both LBMS and LPS. It uses flowline time scheduling and has a make ready approach similar to what we find in the look-ahead planning in LPS. It does however differ from LPS at one point: While LPS on the detailed level uses week plans, TP planes the single task (or work package) in one entity, disregarding the duration.

Summing up the plan contents focused by Task Planning:

1. A holistic approach, seeing the tasks from six different angles
2. The single task is planned in one entity, unregarding the duration

THE LAST PLANNER SYSTEM (LPS)

Although LPS (Ballard, 2000) is mainly focusing on the planning process, it also has focus on some specific issues regarding plan contents. LPS is a planning system consisting of four or more planning levels[10]. Each planning level has a specific purpose. The criteria of goodness of the plan will therefore be specific for the different planning levels. The first criteria we find on the level of the main and phase schedule. This is to establish a feasible strategic schedule with good sequence of activities. Secondly: In the phase scheduling session the different trades write one task on each post-it note. These tasks should be independent, that is they can be executed without the interference of other trades. The third is that the week schedule should only consist of sound tasks. Sound tasks are tasks with all preconditions for production in place (Koskela, 1999). This is achieved through the look-ahead planning.

Summing up the plan contents focused by LPS we find

1. Good sequence of activities
2. Single craft activities (independent tasks)
3. Sound activities

DISCUSSION

The Transformation – Flow – Value theory of Koskela (2000) sees production as a flow of transformations. The flow is flow in time and space, the transformations are what we in scheduling refer to as tasks or activities. Basically scheduling can

[10] The original version of LPS (Ballard, 2000) has four planning levels. Some later developed versions have extended the number of levels to five and six (Ballard et al. 2009; Veidekke 2014)

therefore be seen as the determination of the connections in time and space between the tasks[11]. In our discussion and the succeeding proposed list of criteria for a good plan, we will use this as our structural approach. First we look at the tasks as such, then we look into their relationship in time and space. A good plan is fit for purpose and is being used. This issue is therefore addressed in a separate section. Both tasks, resources, time and space can be used as buffers, and the plan has to be in compliance with the framework conditions. We will therefore also discuss these two issues in sections of their own, before we present our proposed list of criteria[12].

THE TASKS

An underlying assumption in CPM, LBMS and LPS is that the tasks that will be done are to a very large degree identified and in the plan (that the plan is "complete"). Fireman, Formoso and Isatto (2013) and Leão, Formoso and Isatto (2014) have discovered that this is not necessarily the case. In case studies they find that a substantial amount of the executed tasks and work packages are not in the plan. They call these work packages or tasks informal. The number of informal work packages is highly variable[13] and the reasons are various. Typical reasons can be rework and crews going back to finish unfinished work. Due to these reasons new tasks emerge as the project progresses, and these new tasks are often not included in any plan.[14]

THE USE OF TIME

Bølviken and Kalsaas (2011) find that good flow in time is the combination of two dimensions: A high production volume (intensity / throughput) and a uniform production volume per time unit (uniformity / smoothness / lack of mura). In terms of criteria for a good plan this translates to the right project duration and as steady and smooth levelling of production as possible.

Even though correct logic is an underlying precondition for a plan to be good, Galloway (2005) reports that a substantial share of owners and contractors see logic abuse as a primary disadvantage to CPM scheduling. We therefore agree with Kenley and Seppänen (2010) that correct logic should be an explicit criterion for a good plan.

Should we introduce a takt in the plan? There must be buffers in a takt system coming from production that is not running according to takt. If one is to use Takt

[11] Kenley and Seppänen (2010) divide planning concepts into two groups, activity-based and location-based concepts.

[12] During the review process one of the reviewers made us aware of the fact that Kenley and Seppänen (2010) ask the same question as the title of the present paper and propose a list of criteria as an answer to the question (pp. 202-203). While we approach the issue from the perspective of LPS, they approach it from a LBMS perspective. They do however not present the reasoning behind the structure and contents of their list. We have therefore in our discussions only to a limited degree been able to draw upon their work.

[13] Fireman, Formoso and Isatto (2013) find that the number of informal work packages can reach more than 80 % of the total number of work packages! (An average informal work package will usually be smaller than other work packages.) The case study of Leão, Formoso and Isatto (2014) had an average of 34 % informal work packages.

[14] Another thing is that a share of tasks may be deliberatively left out of the plan. According to Kenley and Seppänen (2010) tasks that can be done flexibly, do not require special skills and do not have a large work content, can be left unscheduled and be used as workable backlog. They say that at least 80 % of the workers hours should be scheduled accurately, but do not give any argument for this specific figure (pp. 217-218).

Planning, the question therefore seems to be which projects or parts of projects should and should not be run with takt[15]. Seppänen (2014) finds that Takt Planning can be applicable in some types of projects, but that it can also be a risky strategy. It is therefore hard to see Takt Planning as a universal plan approach in construction and we will not include takt as a criterion in our proposed list.

THE USE OF SPACE

In manufacturing the intermediate product is moving through production. The utilization of space is therefore handled in the planning of the factory layout and not in the everyday planning of production. In construction production is moving through the product. The utilization of space is therefore changing continuously and has to be taken care of through the planning. In contrast to the other planning systems LBMS and Takt Planning are focusing explicitly on space as a constraint and a production resource.

FIT FOR PURPOSE

One of the basic principles of LPS is according to Ballard, Hammond and Nickerson (2009) to plan in greater detail as you get closer to doing the work. Although this principle is obviously common sense, CPM is not in compliance with it. CPM assumes that it is both possible and desirable to plan in great detail long in advance. As we see it, this assumption is based on an underlying understanding of construction as a more stable and predictable process than what it actually is. On the other hand Agile is developed to comply with projects that are less predictable and can have more adjustable goals than what we usually find in construction. Generally speaking, the plan should have a level of detail that is consistent with the level of variability in the project and the level of detail should increase the closer to execution one gets.

Any plan system will have (at least) two principal plan levels: A strategic top level (typically a main/master or phase schedule) and an operational detailed level (typically a week or day schedule). In LPS the interconnection between these two levels is established through a separate plan level, the look-ahead plan. A main focus in CPM is the main schedule and the break down of this in a work breakdown structure. The weekly plan is made simply by making an extract of the work breakdown structure. This creates a push mechanism from the main to the week schedule. Moving on to Agile we find a highly decentralized work process and no plan structure as such. What we find instead is a product backlog replacing the main schedule, control meetings after each Sprint replacing the look-ahead process of LPS and daily Scrum meetings replacing the week plans of CPM and LPS. This constitutes a focus of Agile totally opposite that of CPM with LPS somewhat in between. In Agile the main focus is on daily Scrum meetings and continuous flexible short term planning. The goal of the project is represented by the product backlog, but can also be changed as the project proceeds.

LPS was developed through a critique of CPM. An important goals with LPS was to create a make ready process securing that the tasks on the week plan can really be completed (are sound). This is achieved through the constraint analyses and the look-

[15] The case study by Frandson, Berghede and Tommelein (2013) describes Takt Planning used in a limited part of a project.

ahead plan. The look-ahead plan of LPS is a totally new construct compared to CPM and can be seen as a main strategic focus of LPS. Compared to CPM and Agile, LPS has a balanced focus both on the high and low levels of planning.

A project manager once said to one of the authors: “I plan to tell others what I think”. The term planning often refers to several activities: Analysis, decisions, documentation, communication, follow up and control. An important element in these activities is obviously communication internally in the group doing the planning and externally to parties that have not been involved in the planning. The plan should therefore have a structure and layout with intuitive and visual qualities making it easy to understand and use. What these qualities are will depend on by whom the plan is to be used.

THE LEVEL OF BUFFERS

Buffers are waste. When buffering, specific types of waste (the buffers) are deliberatively introduced into the production system in order to establish a satisfactory level of flow and thereby reduce the total amount of waste in the system. There are buffers in all real life production systems, the point is to reduce them to the minimum necessary to maintain a level flow (Bølviken, Rooke and Koskela, 2014). Buffers can be found both inside the project (e. g. a backlog of tasks ready for execution) and outside (e. g. resources that can be called for). Both tasks, resources, time and space can be used as buffers. Flexibility can be seen as a precondition for the availability of the buffers, but can also be seen as a buffer itself.

The amount of buffers needed in a production system will be a function of the variability of the system: the higher the variability, the higher amount of buffers is needed. Because the variability of the construction process is normally high, it can be of critical importance to have the optimal level of buffers in the plan (not too high, not too low).

COMPLIANCE WITH THE FRAMEWORK CONDITIONS

All projects will rely on explicit and implicit, internal and external framework conditions. This can be the availability of resources, time frames, physical boundaries, costs, contractual risk, etc. (see the description of Task Planning). A good plan should make important external and internal framework conditions explicit and thereby make it possible to have them under surveillance.

CONCLUSION – CRITERIA FOR A GOOD PLAN

Based on the presented plan concepts and the discussion above, we propose the list of criteria presented in Table 1. It also indicates which criteria are inspired by which of the discussed planning concepts and which are mainly based on the discussion in the present paper.

The next step in our work with the topic of this paper will be to test the use of the proposed list in projects using LPS. The goal of this testing will be to find out if the list will turn out to be useful and how the use of the list could be integrated into the LPS planning process.

Table 1: Proposed criteria for a good plan

	Critical Path	Location Based	Takt Planning	Critical Chain	Agile	Task Planning	Last Planner	Present paper
The tasks								
1. All major and important tasks are in the plan								x
2. Independent tasks only (ideally)		x	x				x	
3. Sound tasks only (in short term plans)							x	
4. The preconditions for the tasks to become sound are identified (in long term plans)						x	x	
5. Identified bottlenecks			x	x				
6. Resources are available						x	x	
7. Suitable level of task and resource buffers			x				x	
The use of time								
1. Right sequence and correct logic	x	x	x			x	x	
2. The trades have continuous work (ideally)		x					x	
3. Suitable level of duration tightness and time buffers	x	x		x				
4. Duration is in compliance with the framework conditions	x	x	x				x	
The use of space								
1. A good division in zones		x	x					
2. Suitable construction direction		x	x					
3. One trade at a time in each zone (ideally)		x	x					
4. The use of space is in compliance with the framework conditions								x
5. Suitable level of space buffers		x						
Fit for purpose								
1. Suitable level of detail					x	x	x	
2. Good visual presentation		x						
3. Good intuitive quality								x
4. In compliance with contractual demands	x							

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