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Lean Project Planning in Shipbuilding

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Lean Project Planning (LPP) is a new approach for project planning that has been developed from the Last Planner System to overcome shortcomings in the Earned Value Management approach. In this paper, we investigate how LPP has been successfully used in shipbuilding of a so called Platform Supply Vessel. Due to the highly advanced vessel, we managed to stress-test the approach and found a number of improvements to be made. However, the overall judgment is that LPP is a success. By now, these improvements are more or less implemented except those relevant for the engineering part. When it comes to the engineering processes further improvements are still needed.

Keywords: operations (general); scheduling, shipbuilding

1. Introduction

"Knowledge begins and ends in experience, but it does not end in the experience in which it begins."—Clarence Irving Lewis

Shipbuilding is an industry in which project work is the norm. Despite this, it is easy to find countless cases of poorly planned and executed projects. The approaches used in shipbuilding vary from poorly conceived and problematic to the very opposite. The most recognized and possibly one of the most useful and meaningful planning and reporting tools for projects in general, however, is the Earned Value Management (EVM) method (Sumara & Goodpasture 1997). It has some good performance metrics such as the Cost Performance Index (CPI), projects using it has a consistent, and predictable performance history and after just 15% to 20% completion of the project, we can predict cost at completion within a finite range of values (Fleming & Koppelman 2005). Despite these advantages, which makes EVM a good point of departure for further development, Yong-Woo and Ballard (2000) have shown that the approach suffers from the limiting assumption that activities and cost accounts are independent and by "making BCWP (earned value) a priority in releasing assignments to the field, which prevents quality assignments, which in turn results in unreliability of work flow. It is also recognized that EVM can be too complicated for many to master (Fleming & Koppelman 2005).

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Consequently, this led to a search of better methods. The author came across the Last Planner System (LPS) some years ago and while being a Managing Director of one the shipyards in Vard Group AS (Vard in short), LPS was implemented. However, some problems were identified, particularly the linkage upward to the higher-level plans for keeping track of progress. Consequently, the approach was developed further by including some aspect of EVM. This revised version of LPS we termed Lean Project Planning (LPP) and it became essentially a synthesis of EVM and LPS with an explication of planning as a communication process and not focus on the plan per se.

In this article, a case is presented to show how LPP works. The full theoretical explanation of LPP is presented by Emblemsvåg (2014) to which interested readers are referred. A brief overview of the approach is provided in Section 2. We also have to discuss the peculiarities of shipbuilding because construction, shipbuilding, and projects in general have their peculiarities that an approach must handle. This is done in Section 3. As a result of the transparency of the shipbuilding industry, we have to be careful with what we present of numbers and s-curves. This said, the case will illustrate the approach quite well and further improvement is identified and discussed in Section 5. Conclusions are provided in Section 6.

2. A brief introduction to lean project planning

LPP is depicted in Fig. 1. First, we notice that the planning system distinguished between the system part and the planning process part. The system part we implement is Primavera P6, whereas the planning process part follows the LPS thinking and

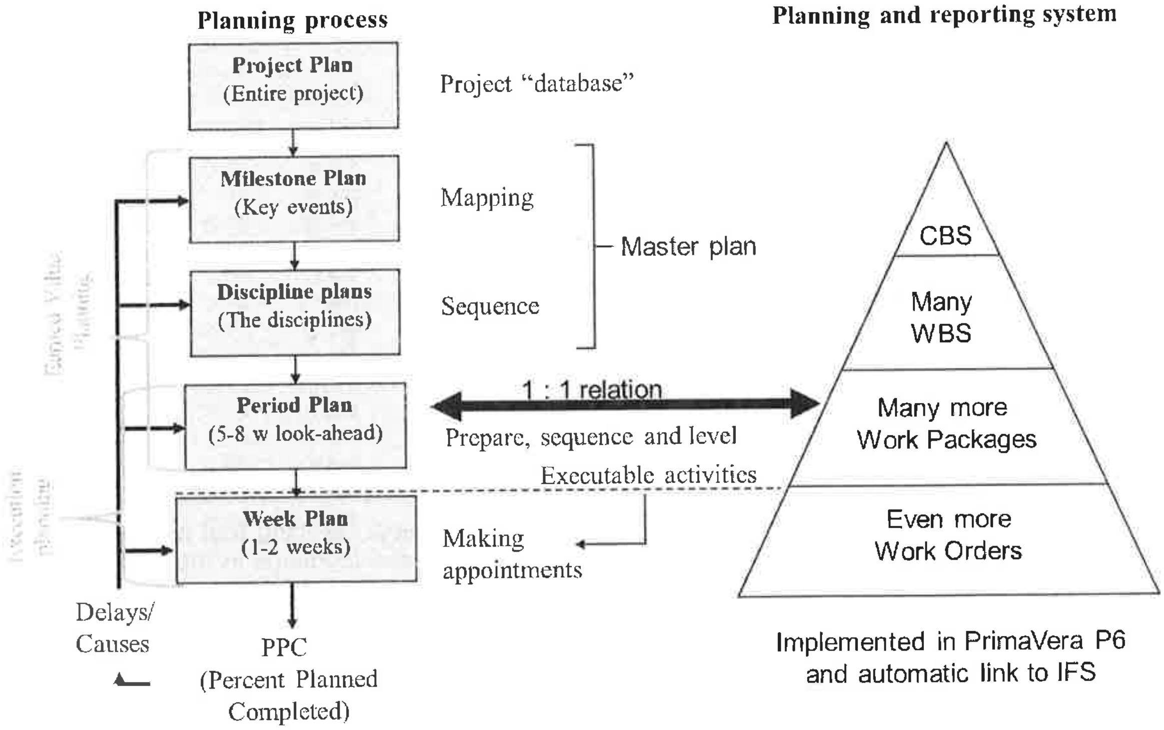

Fig. 1 Lean project planning overview

some EVM elements. On top we have the Project Plan, which is essentially the entire database found in Primavera.

The first plan is the Milestone Plan that maps out key events of the entire project. This is defined early, but the number of milestones is less than 25. Then, we have plans for the major disciplines in which we sequence the activities to work effectively and to prevent rework and other nonvalue-added work. Together, the Milestone Plan and the Sequence Plans constitute a Master Plan. These plans see the whole project execution horizon. So far, this is quite the standard planning approach.

In the next step, the marriage between EVM and LPS takes place. This is the Period Plan level, and a Period Plan is a plan that looks ahead 5 to 8 weeks, i.e., a given period, continuously. The introduction of Period Plans facilitates the look-ahead functionality of LPS and greatly improves the EVM reliability as well. The fact that these plans focus only 5 to 8 weeks ahead is just as important as the fact that they look ahead. Our strategy is that by start following up closely 5 to 8 weeks ahead, we can maneuver out of problems we have not identified. Long leading time items are, of course, followed up before the 8-week horizon. Such items typically include procurement of major components.

The marriage of EVM and LPS is achieved operationally by defining work packages so that we get a 1:1 relation (in most cases) between activities in the Period Plan and these work packages. We also do our utmost to avoid activities lasting longer than 8 weeks. This gives a very good way of tracking physical progress; the CPI gives physical meaning to the supervisors and the EVM becomes difficult to manipulate, which is one of the worries voiced by Kim and Ballard (2000). LPS also gains by being linked into the EVM strengths.

We have also solved the problem of managers releasing work to get nice numbers by instituting the seven preconditions for execution as introduced by Koskela (2000) and thereby forcing quality assignments and controlling Work In Progress (WIP):

1. Preceding work—preceding work must be completed.
2. Personnel—personnel for the work must be available.
3. Materials—the materials necessary for completing the work must be available.
4. Area—the area the work requires must be available and ready.
5. Information—the information necessary to complete the work must be available.
6. Tools—the tools and equipment necessary for completing the work must be available.
7. External conditions—other conditions external to the project must be favorable.

The system blocks time registration on activities that do not have quality assignments, that is, activities in which one of the seven preconditions for execution are not fulfilled. Thus, people who try to game the system will soon find themselves in problems and they are the ones who will end up looking like fools in the weekly lean meeting where the commitment planning takes place.

In this way, we use a combination of IT systems and social cooperation from discipline to make sure the system is not gamed and the WIP is controlled. This explicit control of WIP is what makes the planning system conforming according to the lean principles on an operational level, hence justifying use of the term "lean."

People who cannot live according to this discipline receive some training, but this is mostly about attitudes and people with the wrong attitudes are hard to change and will therefore face disciplinary cases. The important part of this, however, is that this meeting discipline is communicated in advance so it is predictable. Then, people accept it as normal. Also, after awhile, people understand why it has to be so and also promote it themselves. Equal treatment of people becomes the norm and people understand that this discipline is necessary to keep the meetings focused, short, and highly effective. The only way supervisors and others can game the system in the short run is by including activities that are partially finished on the week plan or reporting greater progress than what is the case. However, as a result of the fact that we limit duration of activities by 8 weeks, they can only get good numbers in the short run. In reality, the project team will normally reveal these people after a few weeks. Thus, we see that EVM and LPS can mutually reinforce each other, which is the main idea behind LPP.

The lowest level in the planning system and planning processes is the Week Plan level. This is essentially a worklist for every supervisor and his or her team of foremen and workers, which is derived from the Period Plan and coordinated across all disciplines in the lean meeting. The amount of lines in the Week Plans are much higher than in the Period Plans but Week Plans are not planned in the traditional sense; the foremen and supervisors pull work from the Period Plan and put it together in manageable packages for their crew and each such package constitutes a line in the Week Plan. Despite their simplicity, the Week Plans have several important functions:

1. Week Plans are tools of communication and coordination. It is here the communication part of planning is very important because to properly coordinate activities of this detail—can be whole Work Packages (WP) or parts of WPs depending on manning and progress requirements—communication is the only way. No amount of detailed activities in a system can replace communicating to each other.
2. This is what Ballard and Howell (1998) refer to as commitment planning. In the weekly lean meeting, when project members are presenting and discussing these week plans, they make appointments as to what to do, when to do it, and in what sequence. Possible sequencing problems are dealt with right there and then.
3. The regular status review of these Week Plans, in the subsequent lean meeting, is also crucial for performance. Many companies—even Fortune 500 companies—are what Jackson (2006) refers to as Plan-Do companies. The real secret of execution lies in "follow-up" (Check and Act); thus, complete the whole sequence of Plan–Do–Check–Act.

To keep track of how well we execute the project, we use the Percent Planned Complete (PPC) measure from LPS, and we use s-curves, CPI from Earned Value Project Management, to keep overall track of the project. Typically, low PPCs over time lads to low CPI so PPC is a genuine Key Performance Index (KPI) and the CPI is a Key Result Index using the nomenclature outlined in Parmenter (2007).

There are also a couple of principles that are worth noting to illustrate how LPP differ from many planning approaches. One such principles is based on the idea that plans should be detailed as we approach execution and not before. This reduces the need for replanning but more importantly, it increases the maneuverability because effort and time is not wasted on updating detailed plans well beyond realistic planning horizon for detailed plans.

Another principle is that those who know the jobs must do the planning. The echoes the go and see for yourself to thoroughly understand the situation (*genchi genbutsu*) principle found in lean production (Liker 2004). In other words, foremen, supervisors, and coordinators do not get the plans in their hand and just have to execute/do; they are an integral part of the process of planning, doing, checking, and acting. The most startling consequence for many, however, is that a logical consequence of this is that the planner is not planning. The planner facilitates the planning process, manages the planning tool, analyzes reports, and so on, but sets no dates, defines no durations, and gives no hour consumption estimates unless those responsible for planning have first made up their mind or ask for input from previous projects with a similar scope of work.

Finally, it is important to highlight the difference between project planning and production planning as we see in Vard. In many companies, these terms are almost used interchangeably differing only in that production planning concerns the production part of the project. They are therefore methodologically quite similar. We try to promote a view in which project planning concerns the planning of a complete project, whereas production planning concerns planning all the work in a workshop for a given calendar period. Production planning is therefore essentially portfolio planning focusing on flow and because it encompasses a single workshop, it can be more detailed, whereas project planning concerns a project and focuses primarily on coordination. Typical lean manufacturing systems for planning such as *kanban* or ConWIP can also be used for production planning or highly detailed factory management systems. Such visible planning systems are difficult for a project because it is typically geographically distributed.

This was a very brief introduction to LPP, but hopefully sufficient to help people understand that the system is based on a limited number of well-conceived principles found in lean thinking.

3. The peculiarities of construction and shipbuilding

Every company and industry seems to believe they are special, for example, even in manufacturing claims of uniqueness abound (Plossl 1991). Some industries such as construction and shipbuilding do have some peculiarities, not necessarily very fundamental, but enough to warrant adaptations of tools, approaches, and methods from other industries. Much of the lean construction research has naturally focused on the construction industry, and Nam and Tatum (1988) and Warszawski (1990) have identified four peculiarities for construction industry that set it apart from manufacturing:

1. One-of-a-kind nature of projects;
2. Site production;
3. Temporary multiorganization; and
4. Regulatory intervention.

As a result of these four peculiarities, construction work becomes complex and uncertain (Koskela 1992). However, there are remedies; Koskela (1992) has compiled an overview presented in Table 1. As far as this author is aware of, no such study of peculiarities in shipbuilding has been conducted. However, based on experience in shipbuilding in the offshore market segment where this case applies, the four peculiarities that Koskela (1992) mentions count in shipbuilding as well but to various degrees:

1. One-of-a-kind nature of projects—this is definitively true in the market segment Vard operates in that offshore segment vessels may change substantially from contracting to delivery.
2. Site production—shipyards do have an advantage over the construction industry here because sites are the same, more like in manufacturing.

Table 1 Some problems related to construction peculiarities and their solutions

Peculiarity	Process Control* Problem	Process Improvement† Problem	Structural Solution	Operational Solutions for Control	Operational Solutions for Improvement
One-of-a-kind	• No prototype cycles • Unsystematic client input • Coordination of uncertain activities	• One-of-a-kind processes do not repeat; thus, long-term improvement questionable	• Minimize the one-of-a-kind content in the project	• Upfront requirements analysis • Set up artificial cycles • Buffer uncertain tasks	• Enhance flexibility of products and services to cover a wider variety of needs • Gather feedback information from earlier projects
Site production	• External uncertainties: weather, etc • Internal uncertainties and complexities: flow interdependencies, changing layout, variability of productivity of manual work	• Difficulty in transferring improvement across sites solely in procedures and skills	• Minimize the activities of the site in any material flow	• Use enclosures, etc, for eliminating external uncertainty • Detailed and continuous planning • Multiskilled work teams	• Enhance planning and risk analysis capability • Systematized work procedures
Temporary organization	• Internal uncertainties: exchange of information across organization borders (flow disconnects)	• Difficulty in stimulating and accumulating improvement across organization borders	• Minimize temporary organizational interfaces (interdependencies)	• Team-building during the project	• Integrated flows through partnerships
Regulatory intervention	• External uncertainty: approval delay			• Compression of approval cycle • Self-inspection	

Source: Koskela (1992).
*Process control refers to the management of a project.
†Process improvement refers to the development efforts of the permanent organization in construction (designing, manufacturing of materials and components, contracting).

3. Temporary multiorganization—to some extent, this is also the case for shipyards because subcontracting is used to a large extent (the Norwegian yards in Vard, for example, run at more than 50% with subcontracting), but to be fair, the construction industry is probably more temporary in its nature here too.
4. Regulatory intervention—codes do change in the construction industry, but probably not as much as for vessels in the offshore market segment where vessels are regularly contracted to deliver services for the oil and gas industry on the edge of known technology while at the same time having a very strict safety regime as a result of the inherent dangers in the oil and gas industry.

In addition, there is a fifth peculiarity in shipbuilding that is probably unique to shipbuilding as also indicated by the Leader SHIP High Level Advisory Group 2015 (2003). As a result of the technical complexity of ships in combination with the importance to offer short delivery times, almost every ship (except the simplest, highly standardized ones) are put into engineering and production before all engineering issues are solved. For example, we can start engineering a vessel only knowing the footprint of a component and during the engineering, the supplier of the component provides an increasing amount of technical documentation so that when the vessel is ready for outfitting in production, all issues are resolved. Therefore, in shipbuilding, we introduce the term "project component" to denote components that are developed during the project and this is in contrast to "articles" that are predefined and just procured according to the needs of production.

In summary, it is believed here that the construction industry probably does have a higher number of peculiarities than shipbuilding. However, the products are technologically simpler than offshore vessels, which make the information flow easier to handle. Therefore, it is fair to say that although the construction industry has numerically more, but simpler, peculiarities, shipbuilding for the offshore market segment has numerically fewer but more challenging peculiarities. In particular, it is worth noting the very demanding design and engineering of a technologically advanced solution taking place often almost concurrently with production. This makes planning and execution demanding. Alternatively, some shipbuilders compensate using time as buffer, but this is not our strategy. Vard is aiming for becoming the best in flexibility, delivery precision, and short delivery time while keeping cost at parity. (The term "parity" is used by Porter (1985) to denote a cost level, for example, that is such that although the cost level is not equal to competition in absolute monetary terms, it is still sufficiently low to not become an obstacle for competing [winning contracts in the context of shipbuilding]). Today, we believe we are among the best, but we can still improve.

Next, a very demanding project is presented, in which we applied LPP for the second time. This was a project (BN 738, named Skandi Gamma) that gave us much insight for further improvement of the LPP approach, which is why it is chosen here.

4. Case study: implementing lean project planning at Vard Group AS Søviknes

In this case, we are going to look at how Vard in Norway implemented LPP in the Søviknes shipyard during the period the author was Managing Director there. The Brattvaag shipyard in Vard was actually the first to start the lean journey, but it was at Søviknes that it gained momentum. One of the major value propositions we offer to our customers is flexibility with very high delivery precision (in 2010 to 2012, it was 100%) and relatively short delivery times. The combinations of high flexibility, high delivery precision, relatively short delivery times, and advanced vessels make planning and execution demanding. This is why we work on improving our planning system.

4.1. Planning and execution of the outfitting stage of a platform supply vessel

Before looking at the planning and execution of Skandi Gamma depicted in Fig. 2, it is useful to get acquainted with the vessel to better understand the complexities planning must be a part of. First, however, be aware that in shipbuilding, we use Build Numbers (BN) or Yard Numbers and the like to assign production slots, and for Skandi Gamma, the corresponding BN is 738. All vessels have so-called main particulars that highlight some critical dimensions, and for BN 738, they are:

- Length overall 94.9 m;
- Breadth molded 20.0 m;
- Depth main deck 8.0 m;
- Gross tonnage 5054 metric tonnes; and
- Speed at 4.3 m draught 16.0 knots.

Furthermore, it is worth noting that BN 738 has:

- Cargo capacity of 4750 deadweight tonnes;
- Accommodation for 25 persons;
- A large multifunctional cargo system that allows flexible use of cargo tanks underneath the deck (Fig. 3);
- Wärtsila dual-fuel engines (diesel and Liquid Natural Gas) that produce in total 7830 kW;
- The propulsion is by two Rolls-Royce Contaz thrusters that yield 4400 kW in total and forward there are two Rolls-Royce tunnel thrusters that produce 1760 kW and a retractable thruster that produces 880 kW for easy maneuvering (Fig. 3); and
- The vessel also satisfies all class requirements for the highest levels for such vessels.

As a result of the level of sophistication of the cargo system and the dual-fuel engines, there was a significant amount of engineering performed concurrently with the building process and this also meant that the delivery date was a range at this specific vessel and not a fixed date. This is very rarely the case, but Skandi Gamma was so challenging that our customer granted us a delivery range and not a specific date. The complexity of Skandi Gamma can be best described by the fact that it has over 7000 I/Os, whereas most vessels have barely 3000. Nonetheless, the project went well and was executed according to the milestone plan (Fig. 4). There was only one delay—the sea trial was delayed by 1 week but without any consequences for delivery. So, it is obvious that from a project management perspective, the execution of this project was very good in that the vessel was delivered on time and with agreed quality.

Shipbuilders will, of course, raise a number of questions regarding details in the Key Milestone Plan such as the time

Fig. 2 Skandi Gamma (BN 738) at sea

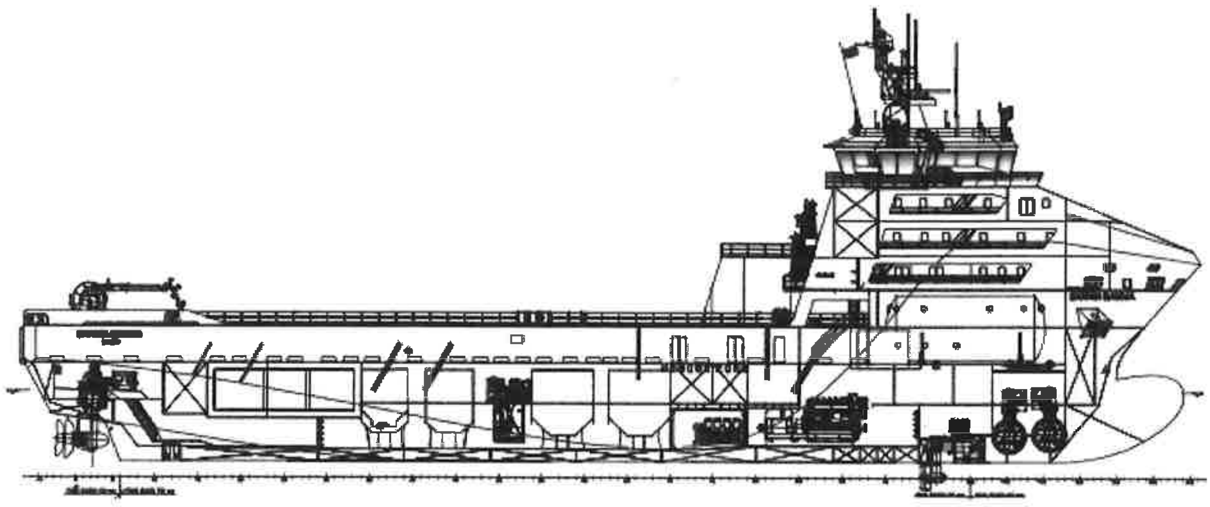

Fig. 3 Cross-sectional view of Skandi Gamma

lag between effective contract and start steel cutting. This may seem that we spent an awful amount of time on engineering, but the reality is that at the time, there was a big boom in the market and the shipyard had people in other projects before they could attend to this one. On top of this, during market booms, the accessibility of large critical components such as main engines, propellers, and thrusters may be very poor, thus inducing long delivery times as well as poor delivery precision. Finally, this vessel had a number of innovations and huge degree of complexity that actually did require a significant amount of engineering. All this was reflected in the delivery time also and was well understood by the customer.

To understand how we married EVM and LPS in this case, the best is to focus on the period plan level (Fig. 5). The marriage takes place primarily in the shape of the 1:1 relation between the period plan and WP. In Fig. 5 we can see 10 lines of the Period Plan that all in all constituted 156 lines.

There are a number of comments to make:

1. Some work breakdown structure (WBS) constitutes of a number of WP and each WP is normally a separate activity. For example, WBS 894 constitutes three WPs.
2. Some WPs have execution times longer than the recommended 8 weeks. Significant effort was made avoiding this, but sometimes, it is impossible to avoid. Later, we have become more skilled in splitting up long activities by realizing that often ship outfitting constitutes of three parts: 1) foundations and the like, 2) installation and testing, and 3) commissioning.
3. We planned on week and not date. This has later been changed because of communication difficulties.
4. All activities are WIP although two of them strictly speaking are not executable as a result of the lack of material (0 in the

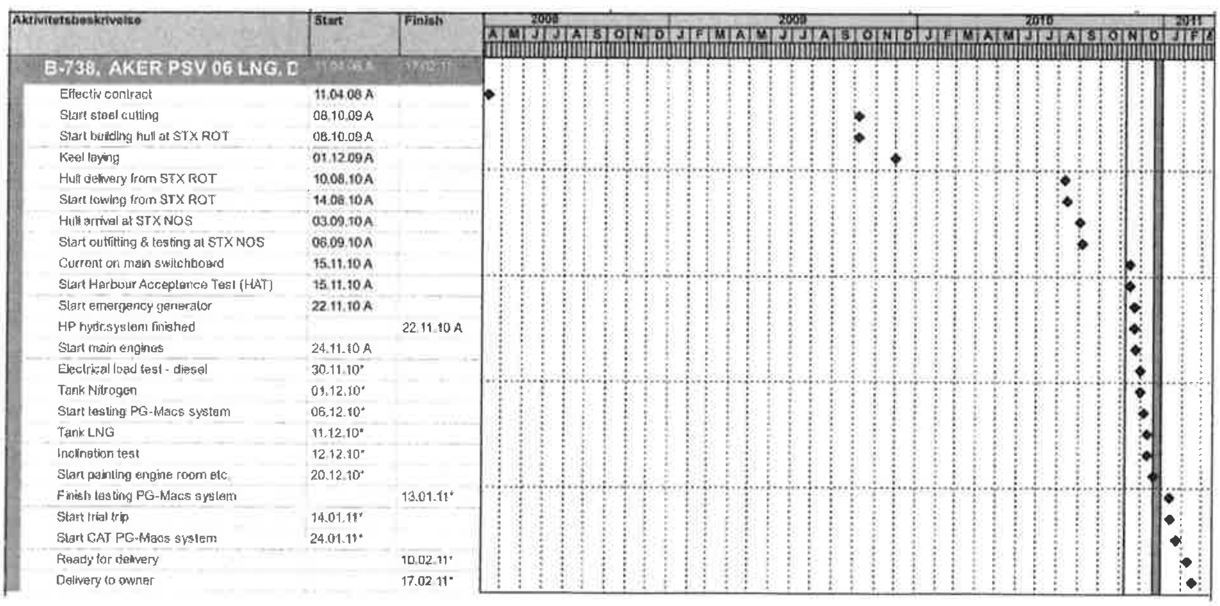

Fig. 4 Key milestones of BN 738

WBS	Activity name	Planned start [week]	Planned finish [week]	Comments	Resp.	Status	Preceeding work	Information	Materials	People	Tools	Space	External conditions
134	Description	36	39		JTS	WIP	1	1	1	1	1	1	1
601	Description	36	41		OEW	WIP	1	1	0	1	1	1	1
602	Description	36	41		OEW	WIP	1	1	0	1	1	1	1
722	Description	36	46		OS	WIP	1	1	1	1	1	1	1
731	Description	36	45		OS	WIP	1	1	1	1	1	1	1
894	Description 1	36	45		KeM	WIP	1	1	1	1	1	1	1
894	Description 2	36	45		KeM	WIP	1	1	1	1	1	1	1
894	Description 3	36	50		KeM	WIP	1	1	1	1	1	1	1
895	Description 1	36	42		KeM	WIP	1	1	1	1	1	1	1
895	Description 2	36	43		KeM	WIP	1	1	1	1	1	1	1

Fig. 5 Excerpts from the period plan of BN 738

Materials column and the entire cell highlighted). Often it turns out that we can start activities and finish them according to plan although we lack material during early execution. This may sound strange, but the fact is that not all work can be conducted at the same time. So, by focusing on what can be done while procurement pushes the suppliers at fault on delivering quickly to minimize possible interruptions, we can keep production running effectively. This goes to show that maneuverability not only concerns how to flexibly handle variation orders from customers, but also how to maneuver around problems in the supply chain. Hence, with the focus on maneuvering as described in Emblemsvåg (2014), such maneuvering would never work in a highly centralized and bureaucratic planning system. In other words, we see how the LPS system can be used to improve EVM.

5. Activities with zeroes in either one of the seven conditions for execution are being blocked in the clocking system for use. They can only be opened manually and this means that we try to promote a behavior where people register the correct hours on the correct activities no matter what. This fosters learning and improved cost calculation for bidding in the next turn.
6. Other possible statuses are Not Started (NS) and OK (the activity is completed). In this way, we force people to complete what they have started and after using this system, we have greatly reduced activities that remain at 95% to 99% for long periods of time.
7. The WPs where conditions for execution are unsound, i.e., zero in Fig. 5, triggers focus on conditions for execution in the Week Plan (and not just the execution). So, the situation mentioned in item 4 previously would lead to Procurement setting up an activity like "As quickly as possible secure Materials for WBSs 601 and 602" on their Week Plan.
8. The number of lines in total may seem rather low—how can such an advanced vessel be outfitted with only 156 WPs? First of all, this does not include all outfitting activities; a significant portion is conducted in our Tulcea shipyard in Romania. Second, it does not include the commissioning plan, but the number of WPs is nonetheless relatively low. The point is communication. It is our belief that plans made more detailed than what can be communicated effectively have little or no value and in some cases, such plans may be outright confusing and ultimately detrimental. It can be detrimental because it not only fails to reach an understanding in the project execution, but it gives a false sense of accuracy, which in turn may lead to important issues being overlooked.

A second way of securing the marriage of EMV and LPS is the Week Plans. The total number of lines in the Week Plans is far greater than the number of lines in the Period Plans. Actually, we never counted, but we are probably talking about thousands of lines. This quite high granularity of assignments in the Week Plan—tracked by the PPC measure—in combination with the 1:1 links between WPs and each line in the Period Plan makes gaming the EVM system hard, which Kim and Ballard (2000) and others are concerned about. Also, when WPs have short durations, the consequences of potential gaming are very low.

A third way, which is not directly related to the planning system as such, is the lean meetings in which the communication takes place in a structured way. At this early stage of development of the LPP, we experimented with how to conduct these meetings as effectively (The terms "effective" and "efficient" are frequently used without any common understanding, which results in poor communication. In this article, effectiveness is defined as a measure of quality of a decision (correctness, completeness, comprehensiveness), whereas efficiency is a measure of the swiftness with which information, which can be used by the decision-maker to make decisions, is generated. These definitions are derived from the more engineering design-oriented definitions provided by Mistree et al. [1990].) and efficiently as possible. We also experimented with who was to attend and also the sequence of the subject matters to be discussed. We came far enough, however, to understand the importance of this without being ready to prescribe a receipt, as it were, for conducting these meetings. Since then, the actual execution of the lean meetings has undergone a large number of improvement cycles. The result of these improvement cycles is that we have now arrived at a standard way of conducting these meetings. Note that in the lean meeting we look ahead 3 weeks, but the coordinator and planner together with a selected few prepare before the meeting and look up to 10 weeks ahead. Experience shows the looking ahead 3 weeks in the lean meeting suffices as long as the coordinator and planner have their 8 to 10 weeks look-ahead process elsewhere.

This standard way outlines the whole weekly sequence of assignments associated with the week plans. This is primarily done at the level of the work leaders. The result is that we have all plans updated; deviations are closed or being closed. Basically, we are planning, not making plans. Another result is that the role of work leaders and coordinators have changed toward more focus on project management-related activities and less of doing activities themselves such as solving concrete shipbuilding problems. This is because that LPP places much more emphasis on coordination, than before, and through communication, which is more time-consuming than merely sending around plans and following them to the extent they feel like it. In this sense, the PPC KPI has also instilled competition among the work leaders and more discipline.

Next, we investigate the business results of LPP in this project.

4.2. Discussion of the business results

Discussing the results of new initiatives is always difficult because nobody knows what the alternative future would hold, and this problem is even greater when vessels are prototypical in design. However, given this highly complex vessel, the fact that it was delivered within time range and that the CPI (as measured in terms of consumed hours and not costs) ended just a little short of 1.00 tells us that execution was quite good. Whether it was better than before, we cannot really tell by other means of anecdotal evidence.

Actually, a major reason we lost CPI score, as we approached the end of the project, was the result of the fact that once the commissioning started, we ended the LPP and focused on the commissioning plans. This resulted in poorly coordinated production for some weeks and we had to spend extra resources getting back on track. This was a valuable lesson for future projects, but it also indicated the importance of the LPP process. In the debriefing of the project team members, nine other suggestions for improvement came through, improvements that are now either partly implemented or completely implemented. Also, on a question regarding whether they would prefer the old planning system to the new, the answers were unanimously in favor of LPP. We also identified five items that had been improved since the last project so what we see is a steady flow and commitment toward improvement. This is perhaps the most valuable outcome at that stage in the implementation in the whole shipyard because when people start focusing on getting better and better, step by step, there is practically speaking no limit to what can be achieved.

Every project by itself holds many new things, and there are always new people to get involved with, so the total amount of change is large. So, after the fifth iteration of improvement, we took a break to let people regain the breath, so to speak—continuous improvement in a project-oriented industry like this is too demanding when the vessels are prototypes and have a relatively short delivery time. Therefore, we shifted focus to work more on the engineering part of the project because this project showed us that there is huge potential for improvement there. Although production typically operates with PPC on approximately 90%, or thereabout, which is significantly higher than what Ballard (2000) reports, the engineers are approximately only half as good at closing their assignments. We can only speculate at this; some reasons might be that 1) engineering assignments are harder to define precisely, 2) engineering assignments can be iterative, 3) engineers often work at several projects at the same time and they are therefore prone to overpromising in each, and, finally, 4) engineers have historically not been subject to such rigor and hence have less training in defining their work clearly, work according to plan, and so on. In addition to this, as expanded on in Section 5, measuring progress in engineering is much harder than in production, which makes the follow-up of engineering work more qualitative and less quantitative than in production.

Finally, it should be emphasized that much more could have been said about the case and LPP in general. However, because this is so central to our execution, we are a little conservative on what we can share.

5. Discussion and improvement of the lean project planning approach

The LPP approach is a natural evolution from LPS—not so much because it is better or different, because it is not really that different or better—but more an explication of it and streamlining it toward the needs of Vard rather than more generically toward construction such as LPS or shipbuilding. The inclusion of EVM is an improvement as long as management is aware of the gaming problems in EVM. This being the case, LPP proves to be a useful synthesis of EVM and LPS at least as judged from the more than 10 projects that have applied it so far.

The explication is important in the next step where we will focus on engineering planning because this is where we see the greatest potential for methodological improvement. We have, however, identified a number of items to improve further also in the production part of LPP such as:

1. The importance of the role of our production coordinators can hardly be overstated, and here we need to develop better training methodology and support. We have started by using the Training Within Industry methodology (Dinero 2005), but there is still some way to go. The training material is developed and has been successfully tested.
2. The links we have today between the Period Plan and the Week Plan are not delineated explicitly; they are based on heuristics as opposed to structures. This makes the planning system somewhat unclear for outsiders and harder to train people in, but because we do not use freshmen as work leaders, it may not be a disadvantage. However, it is something to consider and evaluate.
3. The planning system must also be linked up to the Enterprise Resource Planning (ERP) system, but this is not readily straightforward so we have a job to do here also. This, however, will help us link the planning system to procurement, engineering design, and other processes. The vision is a fully integrated Computer-Aided Design (CAD), ERP, and planning system so that the four processes of CAD, procurement, production, and planning can be seamlessly integrated.

However, the single most important aspect to improve is how we conduct engineering planning. Engineering is increasingly entering the three-dimensional domain so keeping track of hours consumed and using it statistically for future projects is close to irrelevant unless it is done on a very aggregate level, which means we will have big problems measuring physical progress and hence calculate CPI. The fact is that making the drawing today takes 5 minutes, whereas the engineering design process before the printout/plotting can take days, weeks, or even months in some cases. On top of it, they are often iterative. So how do we manage such activities? How do we measure the physical progress correctly so that we can judge whether we are ahead of schedule, on schedule, or behind schedule and also identify root causes of deviations so that solutions can be found quickly and the project can return back on track? This is partly the topic of a PhD study we have undertaken because it turns out that this is an unsolved problem, at least in the literature. Even the state-of-the-art report recently published by The Joint MIT-PMI-INCOSE Community of Practice on Lean in Program Management, which has much insight to offer on a number of issues in engineering, fails to address the problem of measuring physical progress (Oehmen 2012). They are more concerned about communicating the progress to all in a project, thereby implicitly assuming that the measurement of progress is correct.

Here, the insights of Koskela (1992) can also be useful. Traditionally, also engineering planning has been suffering from the problem of focusing solely on conversion and has ignored flow. This mistake must of course not be repeated in a new approach. This means that a new approach may have to focus not only on the engineering design activities, but also on other necessary activities for conducting the actual engineering design to make sure that the entire flow is captured. Another issue in engineering planning is that unlike in the production stage of the projects where activities take place on a single location, in the engineering design stage of the project, we have geographically distributed activities with employees in Norway, Romania, and Croatia and also in different legal units in these countries. How this network of activities can be planned and followed up is a topic requiring further research.

Finally, but not the least, we foresee that research into how to recruit and train coordinators is necessary as a result of their pivotal role in the communication process both in the lean meetings and outside. Traditionally, coordinators have been chosen for their shipbuilding prowess but perhaps we in the future have to emphasize more their ability to coordinate and communicate effectively and handle people in general. Along the same lines, we believe that there is much to improve in the structuring and management of such lean meetings to prevent unnecessary human biases coming into play and hence distort the decision-making process. Biases are well-known problems from the literature (Kahneman & Tversky 1982), yet it has to our knowledge not been properly addressed in planning and execution of projects. This is consequently also something we will work on in the future and another PhD student is now working on these issues.

6. Conclusions

We have investigated how EVM and LPS can be married to reap the best of both in a synthesis-labeled LPP. We have also explicated the importance of planning as communication in project environments and all of this in the context of using planning to secure maneuverability in project execution. It has been developed over 2 years using multiple shipbuilding projects such as the case presented here. Based on the insight from implementations so far, it is clear that LPP actually works quite well; this is the verdict at least from our anecdotal evidence.

However, LPP is no silver bullet. There is extensive need for training of work leaders, coordinators, and project managers because the human side of this is particularly important to study and develop more in addition to the complexity around engineering planning. This said, the fact that planning is now a process of communication seems to be a correct avenue to follow forward based on the research presented in Section 4; it simply makes sense and our anecdotal evidence supports this notion both operationally with respect to hourly consumption compared with budgets for our projects, but also concerning our ability to maneuver, an ability of great strategic market value.

Thus, although it seems that LPP is a finish product, so to speak, the reality is that there is much to improve, which is why we keep working on a number of issues mentioned earlier. These improvement issues, however, do not preclude us from declaring that after years of making plans, we are now finally planning. In the words of Dwight D. Eisenhower: "Plans are nothing; planning is everything."

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