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IMPROVING INTEGRATED PLANNING FOR OFFSHORE O&M PROJECTS WITH LAST PLANNER® PRINCIPLES

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ABSTRACT

The operation and maintenance of offshore energy projects requires careful planning across multiple time horizons, business units, and companies. Integrated Planning and Logistics (IPL) is a system used to help meet this requirement. This research compares an IPL system in use, as well as existing literature, with a mature planning artifact in construction, namely the Last Planner® System (LPS). The research hypothesis was that implementing Last Planner principles could improve IPL system performance. Despite the challenging environmental conditions inherent to offshore work, data from 30 projects revealed that over 90% of not successfully completed activities failed due to causes related to ineffective planning. Research findings indicate that it would be beneficial to include Last Planner® principles in IPL systems. This paper concludes by presenting a hypothesis to test during further deployment of IPL systems on current or new projects.

KEYWORDS

Last Planner® System, Production management, Operation Planning, Integrated Planning and Logistics

INTRODUCTION

Offshore energy (oil and gas) projects require input from thousands of people across different companies, business units, and fields of expertise. With operating expenses up to and over a million dollars a day, there is a high demand to create clear and effective planning systems that can help to maintain the offshore platforms. Integrated Planning and Logistics (IPL) is a system developed through the Integrated Operations (IO) Center, a collaboration between industry and Norges teknisk-naturvitenskapelige universitet i Trondheim (NTNU) in order to facilitate integrated operations (Ramstad, Halvorsen and Holte, 2013). Though the concept of IPL has been developing since 2004, some projects using it still report low plan attainment percentages during the execution phase of operations.

The research question addressed in this paper was: How can principles from the Last Planner® System (LPS), a system initially used in construction, improve IPL

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during operations? The research uses a design science methodology to compare the two planning systems. In design science, artifacts are constructed and tested in order to solve practical problems and generate theory (March and Smith, 1995). First, this paper presents a background of design science research. Second, the two planning systems are introduced and described. Third, data from current projects using IPL are presented in order understand the current state and identify why activities are missed on the execution plan. Fourth, the paper assesses what plan failures occur that the LPS has been designed and tested to avoid or eliminate. Finally, the paper presents a hypothesis to test, provided the changes to IPL are made.

BACKGROUND

RESEARCH METHODOLOGY & DESIGN SCIENCE

March and Smith (1995) described three modes of producing knowledge. Natural science produces theory that explains the causal relationships in the world. Social science describes human behaviour and other social phenomena. Design science is bases itself on prescription and the creation of artifacts and subsequent testing thereof. While similar to case study research, design science is different because the aim of case study research is not necessarily to prescribe. Benefits to using design science are that it creates practical solutions, generates new theory, and narrows the gap between practice and research.

There are four sequential research activities when conducting design science research (March and Smith, 1995). (1) Building the artifact – Constructing an artifact to fit a specific purpose. (2) Evaluating the artifact – How well does it work? (3) Theorizing - Explain why does it work or not work? (4) Justifying – What evidence is there to indicate this conclusion?

Building the artifact starts with descriptive research in order to understand the environment and the problem. Evaluating the performance of the artifact is based on a specific environment and builds further understanding of the problem, generates knowledge for how to improve the solution, and also helps produce more generalized knowledge on the system itself. One risk in design science is over generalizing the benefits of an artifact, so it is important to clearly communicate the specific environment in which the artifact was tested in. Last, design and evaluation activities are practice focused, whereas theorizing and justification are theory focused.

Design science research is cyclical in nature, for the artifacts change over time due to increased problem understanding and the knowledge gained from testing the artifact. In addition, the phase an artifact is in builds environmental context. The environmental context of an artifact is important to understand because an artifact may solve one practical problem in one environment well, but may have unforeseen consequences when it is introduced into another.

Instead of constructing new artifacts, this research first provides background on two existing ones, IPL and the LPS. The artifacts being compared are these two planning systems. The results section evaluates activity misses that occurred in the course of using an IPL system on 30 projects. Based on the data, the researchers theorized why activities were being missed during and hypothesize that changing current planning practice may be beneficial. Justification for this change is given by looking at a case where practices were already adjusted.

INTEGRATED PLANNING AND LOGISTICS (IPL)

The research was conducted in the course of a 6-month internship with a company. According to company documentation, the objective of IPL is to "facilitate safe and efficient development and production of oil and gas". One reason for implementing the system is to address the problem of siloed planning that is departments plan in their own domain but do not have a systematic way of interacting with departments planning in other domains. Integrating the plans of different departments should facilitate the allocation of scarce resources (e.g., time, locations, materials; tools). This in turn should allow for optimized synergies, reduced risk of schedule clashes, improved prioritization of planned work, increased trust in plans, greater reliability of plans, opportunity for the organization to learn, and allow for plans to contain details of sufficient and constant quality.

Figure 1 reflects the company's planning system consisting of multiple tiers. The system is organizationally structured such that the leader of a meeting is always included in the meeting tier above. The meeting frequency and schedule timeframes of each individual plan are based on the demands of the particular project. A difference to highlight here, when comparing offshore- with construction projects, is that the Strategic planning horizon spans a 5-year horizon across multiple projects.

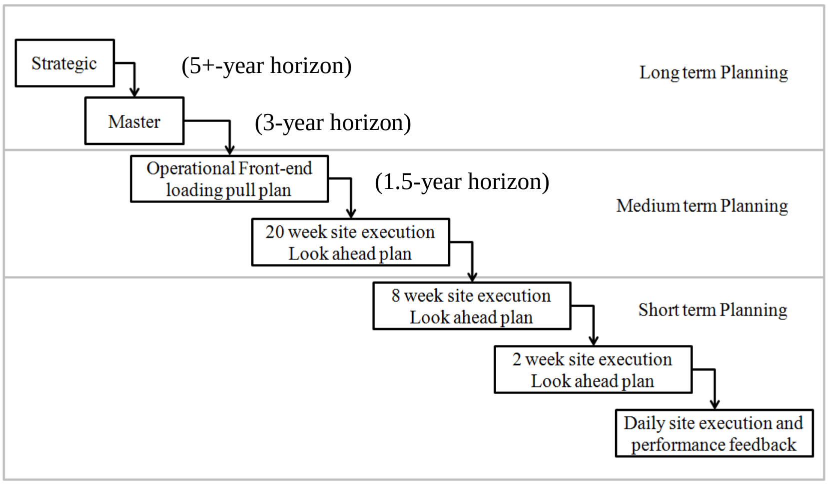

Figure 1 – Example of plan structure

LAST PLANNER® SYSTEM (LPS)

The LPS was developed for construction in the 1990s (Ballard, 2000). The purpose of the planning system was to increase plan reliability, for initial research identified that only about 50% of work planned at the execution level for a given week was completed by the end of the week. Estimators appear to account for this level of plan attainment as well. Thus, if the plan reliability were to increase, then actual production could exceed estimates considerably. As plan reliability increased, the system expanded to improve upstream planning because that was the new bottleneck for production. In all, each process developed as a counter measure to the different problems that emerged while developing the planning system.

The LPS has a hierarchical structure. The philosophy behind the structure is that the further out you plan, the more incorrect the plan will be; and the more detail you plan, the more incorrect the plan will be. Thus it is important to plan at the right level of detail at a given time. At the highest level of the LPS, the master schedule applies to the entire project. A phase schedule is a schedule for a batch of work between two milestones. The lookahead schedule is a schedule that shows work to be made ready; in construction, it typically spans a window of 4 to 6 weeks. At the lowest level, the (weekly) work plan shows what workers have committed to doing the following week.

The first step in the LPS is to plan what **should** be done based on the project objective. This planning goes into the master and phase level planning. The master schedule provides milestones for the project and assesses project feasibility. The phase schedule works backwards from the milestones in order to validate the schedule. This process is called Reverse Phase scheduling, or Pull planning. The purpose of working backwards is to schedule only work that releases work to others. In lean production terms, the work is only being scheduled if a downstream customer requests, or pulls, the work.

The second step in the LPS is to take what **should be** done and screen for what **can** be done. One principle in lean is to not allow defects to move through production systems. Activities are screened for readiness based on the seven flows (Koskela, 1999). The seven flows are: (1) design, (2) components, (3) materials, (4) workers, (5) space, (6) connecting work, (7) external conditions. If the work is not ready or is deemed unlikely to be ready by the scheduled time then it does not move forward on the lookahead schedule. This screening of activities and removal of constraints on the seven flows in the lookahead schedule is known as the Make Ready process.

The third step in the LPS is to commit to work that **will** be done based on the work that **should** and **can be** done. In order to make a reliable commitment, the last planner needs to be able to say no to assignments. A last planner can accept only assignments that meet the following five criteria: (1) definition, (2) size, (3) sequence, (4) soundness, and (5) learning (Ballard and Howell, 2003). Assignments need to be defined and sized correctly so that they can be done within the commitment planning window. At the end of that window they are assessed as either done or not done. There is not a percentage complete assigned at this level due to how percentage metrics can be gamed and, more importantly, the hand-off is key: a follow-on "customer" needs to have all work done in order to proceed with their work. The work is either complete or it is not. In addition, the work needs to be sequenced correctly and the work must be sound (all the prerequisites are complete and the work is ready). Thus, the last planner's assignments meet these five criteria. In the LPS, checking that these criteria are met is known as shielding production (Ballard and Howell, 1998).

The LPS has three metrics: planned percent complete (PPC), tasks anticipated (TA), and tasks made ready (TMR) (Ballard, 1997). PPC is a measure of what percentage of activities planned in the week of execution were completed. TA is a measure of predictability in the planning system and compares common activities between current and past schedules for specific weeks of work (e.g., compare week 3 from last week's schedule to this week's week 2 schedule). TMR measures the ability to remove constraints on future activities and make them ready.

In summation, the focus of the LPS is to identify work that needs to be done, make that work ready, commit only to work that can be done, then perform that work. The final step in the system is to check up on production and identify what was done in order to learn. This learning loop provides the continuous improvement mechanism in the planning system and focuses on improving upon actual plan failures. The three LPS metrics help measure the performance of the system by assessing work performance (PPC), predictability (TA), and the ability to make work ready (TMR). The result of the system is increased throughput, a decrease in accidents on site, and increased planned reliability (Ballard, 2000).

HYPOTHESIS

Four topics in the LPS that may be beneficial to emphasize or adopt in IPL. The topics are (1) work flow metrics in order to enable proactive production control, (2) the concepts of screening and (3) shielding production, and (4) building continuous improvement into the planning process. The hypothesis tested in this research was that activity misses in the schedule would be predominantly caused by reasons the LPS was designed to eliminate.

RESULTS

This research presents data from 30 projects using IPL from a single company. The initial purpose for collecting the data was to identify current practice on the use of IPL in one region in order to develop IPL in a new region. Data was collected from a Primavera 6 web application for the time period of February 2014 to October 2014. The data is comprised of maintenance work and describes why activities were missed at the weekly level. One of 22 disturbance codes was provided every time an activity was not completed (why exactly these 22 remained unclear to the researchers). Table lists these 22 disturbance codes, the disturbance, and the frequency sparkline of the code usage during that time period. In all, the researchers analysed 428 disturbances across the 30 projects with 22 disturbance codes. They analysed unsuccessful activities (disturbances) only and not successfully completed activities. They conducted informal phone interviews for clarification of the data with the head planner of the 30 projects.

Table 1 provides a distribution of the disturbance code usage over the observed time period for all projects. Weather is often cited as a reason for uncertainty and disturbance by offshore workers, nevertheless, only 6% of disturbances cited weather as the cause. In addition, weather affected multiple activities as is evidenced in the sparkline for weather (e.g., data underlying the two spikes in the sparkline on row B4 showed that a storm caused 50% of the disturbances in each of the corresponding weeks). Material related disturbances were recorded in 38% of the disturbances, indicating strongly that work that should be done, should be screened for what can be done. Flight related disturbances were less than 1% of the disturbances and occurred due to inspections being rescheduled. Last, at a minimum 10% of the work being scheduled but not completed was due to planning over the capacity of the offshore workers.

The distribution of disturbances between the projects is positively skewed, for 80% of the projects had less than 5% of the total number of disturbances each. Each project had on average 14.27 disturbances with a standard deviation of 11.77. Some projects had the majority of disturbances, however, data is lacking at this time to gauge whether or not this was simply the result of these projects' sizes.

Table 1 – Disturbance Code Assignment

Code	Description	# of Code Usages	Code Usage as a %	Frequency Sparkline (Feb. – Oct. 2014)
A1	No operator available	2	0.47%	
A2	Asst. Operations / Unplanned ESD start-up	5	1.17%	
A3	Unplanned priority 0 or 1 intervention	11	2.57%	
A4	Assistance projects	9	2.10%	
A5	Permit delay	1	0.23%	
A6	Unplanned ESD start-up	0	0.00%	
B1	No flights	2	0.47%	
B2	Delayed flights	2	0.47%	
B3	No material	61	14.25%	
B4	Bad weather	27	6.31%	
C1	Work prep incomplete	45	10.51%	
C2	Wrong material specified	26	6.07%	
C3	No access	22	5.14%	
D1	Wrong material ordered	14	3.27%	
E1	Material not delivered	62	14.49%	
E2	Vendor not present	22	5.14%	
F1	Excessive hours planned	41	9.58%	
F2	Workflow sequence no applied correctly	7	1.64%	
F3	Planning principles not Applied Correctly	28	6.54%	
G1	Scope change during execution	32	7.48%	
G2	Job prep	7	1.64%	
G3	Sick	2	0.47%	

Figure 2 shows disturbances by week. They appear to be cyclical, perhaps due to the nature of planning execution activities 14 days at a time. They also appear to be increasing at a nonlinear rate. A 2-week moving average trend through the data does not confirm this observation however. Weeks 32, 38, and 39 were the worst. Further analysis shows that each of these weeks had different disturbance codes associated with it, with the exception of material related disturbances consistently occurring in all three weeks. In week 32, 43% of the disturbances were related to materials and another 17% were related to vendors not showing. In week 38, 28% of the disturbances were related to excess hours being planned and 28% were also related to materials. In week 39, 40% of the disturbances were related to weather and 31% were related to materials.

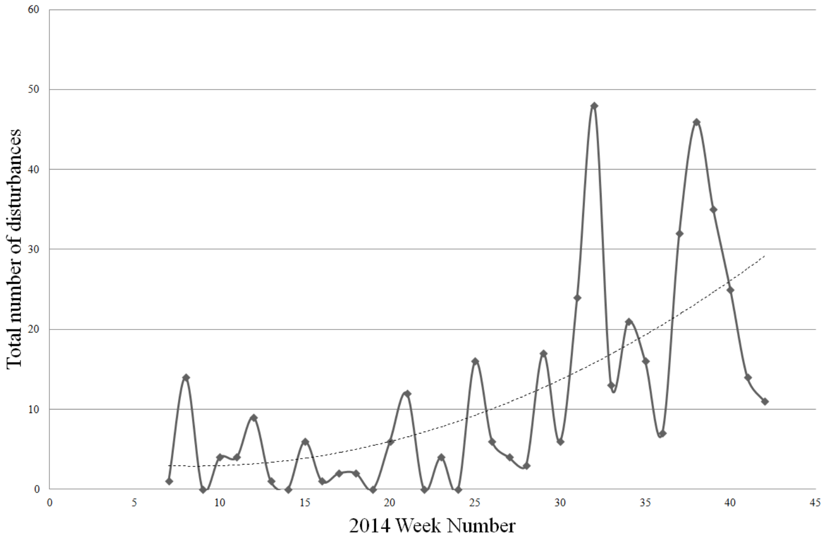

Figure 2 – Disturbances by week for all projects

The head planner was interviewed over the phone to clarify initial findings and understand how data currently was used to promote continuous learning. Every week, each project assessed the previous week in order to identify problems and understand how the plan was executed. Trends in disturbance code usage were not tracked however, so the data presented in this research allowed for new insights into the planning system's performance. Despite not tracking disturbance trend data, planning teams for the projects pursued ways of solving the material related planning disturbances as well as improving work preparations. The head planner was also asked to differentiate between disturbance codes that were outside of the control of planning. Unplanned high priority interventions (occurring from breakdowns or emergencies), sickness, weather, and flights were considered outside of the control of planning, thus they did not have the potential to be reliably screened or shielded for. The remaining 90% of disturbances fell into a category that he agreed the planners have the potential to influence or avoid. Delayed flights may also be prevented by working closer with the flight companies. Last, the increase in disturbances may not be a true increase, but only an increase in the actual reporting for whatever reason (the researchers did not have access to the collection of the data they analysed).

One rule put in place by the head planner had been to not allow work that did not have material ready to be scheduled in the two week execution plan. This rule prevents work of which it is uncertain that it can be done from entering the schedule, so it is an example of shielding. When the head planner started to display the total amount of work hours scheduled without material ready as a metric to the schedulers (Figure 3) that amount rapidly decreased. The first data point shown on September 8th contained nearly 12.5 thousand man hours of work planned without material showing a status ready. As of October 27th, that amount is now showing 573 hours planned.

Data confirming the trend of 12.5 thousand man hours or more planned prior to September 8th was not available to the researchers. The number of materially related disturbances did not decrease as expected, but this could have been caused by an increase in reporting.

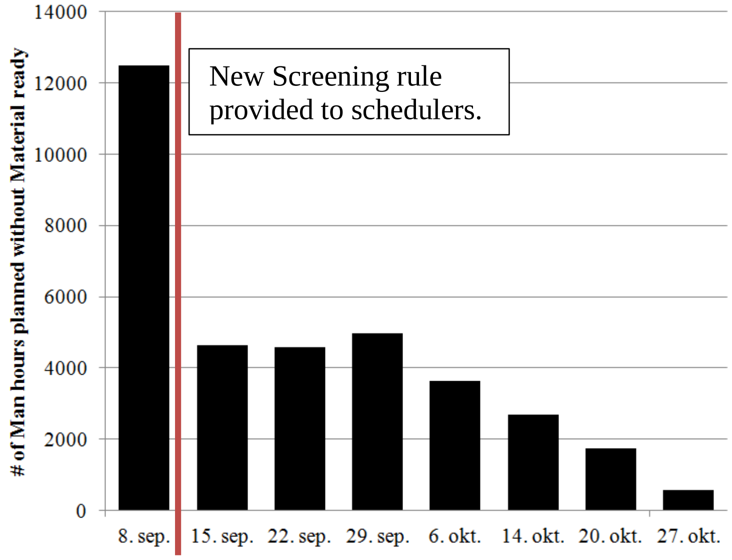

Figure 3 – Number of man hours planned without material showing ready

DISCUSSION

The results from the 30 projects of one IPL implementation at one affiliate indicates that while their IPL system focuses on what should be done, there is a clear disconnect with what can actually be performed at the execution level. Thus, implementing screening and shielding processes would likely increase planning performance of projects using IPL.

The context of the two planning systems is worth discussion. The LPS was developed for construction projects. The master schedule was the highest level, based on the project, and identified if what should be done (i.e., building the project) was feasible. Collaboration between the different parties is between different companies and typically aided through relational contracting (Lichtig, 2006). In general, there is less of a focus on the technological implementation of the system: post-it notes and excel are sufficient to make the system work.

IPL for O&M of offshore platforms is quite different. The network relationships in offshore O&M are not the same as those in construction, thus determining what should go on a plan is much more open for discussion. Collaboration in IPL is primarily within the company between departments. While O&M operations aim to perform proactive preventative maintenance, the inevitable breakdowns of systems and equipment occur. Last, the scale (both in time, 5+ years to daily execution, magnitude, and geographical location of those involved) of planning and execution for offshore operations creates a demand for an IT solution to support all planning.

Continuously improving upon failures and mistakes creates competitive advantage. The LPS incorporates continuous learning by identifying failures in order to perform root cause analysis and eliminate the issues. Furthermore, screening activities and shielding what is scheduled in the execution plan helps identify more problems. While continuous improvement appears in the IPL literature, it is unclear how it is realized in practice. The interview with the head planner revealed that there was no systematic process for continuous improvement in place, though it was still occurring and rules were being implemented to begin to solve problems. While the new rule decreased the total amount of work being scheduled without materials showing ready in the plan, the material related disturbance code usage did not decrease in the past two months.

This data reveals how disturbances codes were assigned to activity misses over a year. If an activity was missed in one week, then appeared in another and missed again, two disturbances were recorded in order to capture every reason and prevent just capturing the last assigned disturbance. However, the cause for a disturbance is subjective because it is up to the senior technician to enter in the cause based on what he or she thinks. The head planner did comment that people would sometimes pick the disturbance code that required the least amount of writing for them to complete. Thus, technicians required some coaching and training to understand the importance of inputting the correct disturbance codes. To highlight one example, a senior technician reported disturbances for material related reasons, but it was later discovered that the correct material was shipped and used to fix a different component. Thus, the real miss was not material related, but occurred due to a change in what was actually executed. One cause for this, as discussed at the 2014 IPL workshop, is that individuals like to fix broken things (Winge, 2014). If the execution plan has an activity for fixing something that does not appear broken, but the technician sees something that is broken, then they may fix the problem that they know exists. Thus, when technicians do not trust that plans actually specify what should be done, they may work on other items not on the plan.

A hypothesis to test in future implementations of IPL is that the adoption of the LPS practices of screening, shielding, continuous learning, and using proactive metrics will improve planning performance. Just one rule that shielded activities on the basis of material readiness decreased planning work hours with unsure or not ready material statuses. Similar screening in earlier stages of planning combined with shielding for other prerequisites could reveal other planning related issues and provide direction for where to improve. Establishing processes for continuous learning based on the data would provide a means to systematically improve.

CONCLUSION

This paper compared the LPS, a system initially developed for project delivery in the construction industry, with IPL, a planning system developed for O&M of offshore oil and gas operations. The literature review identified that IPL emphasizes on collaborating between departments at different scheduling horizons to identify what activities should be performed. The LPS focuses on ensuring that reliable commitments on the execution schedule are made by screening, making work ready, and shielding. Data from 30 projects using IPL practices revealed that over 90% of failures may be linked to not assessing whether the work is ready (screening), not shielding and allowing immature activities to move onto the execution plan, or improper planning. These failures are potentially preventable. A single rule shielded the two week execution plan from activities without ready materials and decreased the amount of planned work without materials from 12,500 man hours to less than 1,000 man hours in under two months. This is significant, first and foremost because all of the work planned into the 2-week schedule needs to be completed (i.e., the schedulers aren't scheduling excess tasks so that the maintenance crews can pull from a large list of tasks and complete what they can: everything on the list should be done). Second, allowing the offshore planners to commit to work that they know can be performed may also surface more production issues and provide additional opportunities to improve planning performance. Third, metrics that assess the ability to screen and make work ready may indicate where production related bottlenecks are occurring. Thus, this research concludes with a hypothesis: incorporating LPS principles of screening, shielding, continuous learning, and using proactive metrics will improve planning performance during maintenance and operations of offshore facilities.

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