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IMPLEMENTATION OF THE LAST PLANNER® SYSTEM ON A PORT PROJECT – EVIDENCE FROM IRELAND

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ABSTRACT

Evidence of using Last Planner System on Port and Maritime projects is scarce in construction literature. This study presents the benefits and challenges accruing from implementing all functions of the Production Planning and Control process on a Port project in Ireland.

This qualitative research adopted a mixed-methods approach utilising a case study design and data collected from semi-structured interviews and observation. Findings highlight productivity and schedule alignment opportunities accruing from a collaborative planning routine and cycle from the Last Planner System application. Challenges included the uniqueness of the Port project and maintaining the team's diligent focus on adherence to the process.

Key lessons reinforce senior leadership support for the implementation, early training and education for the team, effective communication to crew level, utilising digital solutions to support visualisation, and not rushing to digital solutions until a solid understanding of the Last Planner System is in place.

Recommendations suggest Planned Percent Complete focuses on critical path performance, Pull Plan milestones address key land and water-based activity interfaces, and consideration is given to on-going coaching and facilitation to embed Last Planner System principles.

KEYWORDS

Last Planner System, pull planning, lookahead planning, constraints, Planned Percent Complete.

INTRODUCTION

At present, there is minimal published research concerning the implementation of collaborative planning processes, specifically the Last Planner System (LPS), in the execution of maritime projects. Studies exist of implementing LPS on infrastructural projects: Daniel et al. (2016) examined highways in the UK, and Daliri et al. (2021) reported on the Minnevika railway bridge project in Norway. However, there is a dearth of examples from Port and Marine infrastructure projects, and this results in a gap in LPS implementation research.

The execution of marine works requires specialised and sophisticated equipment, including jack-up barges, tugs, and clamshell cranes. These types of machinery are not typically employed in standard inland construction projects, highlighting the unique logistical and operational

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demands of the marine environment (Tam and Shen, 2012). The engineering and construction methodologies used for land-based structures cannot be directly applied to marine settings either. The specific environmental conditions present in marine environments—including variable physical forces and distinctive soil types—demand the adoption of specialised construction materials and techniques (Tam and Shen, 2012; Nebot et al., 2017). These factors challenge the prevailing application of LPS practices and demand specific lookahead coordination of expensive marine plant to ensure efficient work execution.

This study presents a distinct opportunity for both academics and industry practitioners to observe and analyse the implementation of the Last Planner System on a critical marine infrastructure project. The study's objective is to evaluate how LPS was implemented and to determine the challenges and benefits of using LPS on the selected project.

LITERATURE REVIEW

Unreliable planning is a weakness in construction, with research showing that only half of scheduled tasks are completed weekly (Ballard *et al.,* 2007; Liu et al., 2010). Lean Construction (LC) aims to improve workflow reliability, and the Last Planner System (LPS) is a crucial technique for eliminating waste and reducing process variability. Although literature stresses LPS's importance, practical guidance is limited, making real-world implementation challenging.

LPS includes functions such as milestone scheduling, pull planning, look-ahead processes, weekly work planning, daily coordination, and continuous improvement. Planned Percent Complete (PPC) measures workflow reliability; high PPC reflects effective planning and reliable execution (Ballard and Tommelein, 2021, p.37). However, relying solely on PPC risks missing broader schedule issues (Hamzeh *et al.,* 2009; Ballard *et al.,* 2020, Bølviken *et al*., 2025 and Görsch *et al*.,2025). Therefore, using all aspects of LPS is essential to ensure productivity aligns with project milestones. As PPC correlates with productivity, it is essential teams be afforded the best environment for achieving high PPC (Power and Taylor, 2019).

Evidence of using Last Planner System on Port and Maritime projects is scarce in construction literature. Cases exist of using LPS on infrastructure projects; Kassab et al. (2020) and Daliri et al. (2021) published case studies on the implementation challenges encountered on the Minnevika Bridge project. These focused on how to enhance the LPS implementation and did not address how the project delivery was improved or otherwise. Daniel et al. (2016) explored the factors influencing the implementation of LPS on infrastructure projects within the growing practice of Joint Venture (JV) contracting. While identifying several blockers to LPS implementation, the study identified seven factors that would support LPS implementation on JV projects going forward.

Infrastructure projects like roads and rail are linear in nature and cross a wide geographical area, limiting the effectiveness of traditional scheduling and planning methods. Despite these challenges, infrastructure projects are highly valuable and of major strategic importance to a country or region (Dave et al., 2013). Therefore, it is critical that the most effective and innovative methodologies are utilised to ensure safety, quality, cost, and schedule adherence on infrastructure projects. Marine construction projects present distinct challenges that set them apart from traditional land-based works. A sizeable portion of the activities involved are performed underwater, making direct oversight and measurement difficult. In such circumstances, the progress and quality of work can only be effectively assessed using divers and the analysis of survey records.

As noted by Nebot et al. (2017), detailed information on marine conditions—including wave dynamics, currents, and logistical considerations—is vital for the effective planning and implementation and careful evaluation of these elements throughout the project lifecycle is necessary to maintain safety, uphold quality standards, and achieve operational efficiency within challenging marine environments. Recently, growing concern over the environmental

effects of Port development has highlighted the need to minimise negative impacts on ecosystems. A sustainable or green Port is one where authorities and users actively pursue economic growth while prioritising environmental responsibility (PIANC, 2023).

Design and construction risks for construction of a shipping Port and container terminal were examined by Joubert and Pretorius (2020). Pertinent findings related to schedule risk were associated with concrete armour production and placement delays, timely procurement, availability of specialist plant, mismatch between schedule and plant availability to achieve planned production rates, operations congestion on the water, overtopping of waves, and geotechnical changes. Simm and Cruickshank (1998) referred to the obstacles a project might encounter when interfacing with nature, including geotechnical, weather, and seawater risks. Numerous studies (Hanna et al. 2010; Habibi Rad et al., 2022) examined the application of Lean techniques in transport infrastructure projects and disaster recovery on infrastructure projects. Notwithstanding these contributions, there is a distinct absence of case study research showing LPS applied to infrastructure projects.

This research examines the implementation of all functions of LPS on a Port expansion project. The objective of the study is to evaluate how LPS was implemented and to determine the challenges and benefits of using LPS on the selected project.

METHODOLOGY

To address the research objective, a mixed-methods approach utilising a case study was adopted, incorporating semi-structured interviews with key project stakeholders, quantitative analysis of project data such as PPC and Reasons for Non-Completion (RNC), systematic observation through a research diary, and consultant feedback notes provided to the project team. This integrated methodology enabled a comprehensive examination of both the qualitative and quantitative dimensions of LPS implementation on the Port expansion project, facilitating a robust analysis of the challenges encountered and the benefits realised throughout the project lifecycle.

Case studies are popular in construction research because they effectively represent the context in which knowledge is gathered (Green *et al.,* 2010). According to Yin (1993), case studies are beneficial for exploring the 'how and why' of events, providing advantages that quantitative methods may lack. While their generalisability can be questioned, Tellis *(*1997), referencing Hamel et al. (1993) and Yin (1993), argues that the number of cases does not determine a study's value; even a sole case can be valid if it meets research objectives. Fellows and Liu (2020) note that theoretical generalisation is possible when the sample typifies the target population. Any sector or discipline requires numerous well-executed case studies to build a robust body of knowledge (Flyvbjerg, 2006). Saunders (2012) pointed out that selecting the right sample determines whether the research question will be sufficiently answered. As the aim of this research could only be addressed by those directly participating in the LPS implementation, the sample became the contractor's site management team as profiled in Table 1.

The primary question asked to the interviewees was, 'What has been the impact of the Last Planner System on the execution of construction operations on the project? Extension of this question probed about the impact on each interviewee's role, how the schedule was affected, and the challenges encountered.

Semi-structured interviews ensure key topics are addressed while allowing flexibility to adjust questions based on context. This approach lets interviewers adapt to the interviewee, raise new questions from the conversation (Bryman and Bell, 2015), and manage time effectively. Face-to-face interviews also offer the benefit of observing non-verbal cues, such as gestures and facial expressions, adding depth to the interaction.

Structured observation was chosen for its ability to capture PPC and RNC data directly. This improves data quality by observing behaviour rather than relying on surveys (Bryman and Bell, 2015). The assistant planner recorded RNC and PPC weekly and issued this by email to the project team. The previous weeks data was the first agenda item at each Weekly Lookahead and Workplan Coordination meeting. The external consultant visited the project for a full day once every five weeks. The consultant attended the Morning Huddles, Constraint Log reviews, the Weekly Lookahead and Workplan Coordination Meeting, and facilitated the 12-week Pull Plan update with the team. As well as on-the-day feedback, the consultant provided a written feedback and improvement report to the Construction Director and the project team.

Limitations include the single project and the fact that the interviewees are from the same contractor undertaking the work.

THE PROJECT

The project is in Northern Europe, and the Port company is committing significant investment in facility upgrades, including a new quay wall at Berth 52 East and a major roll on -roll off complex at Berth 53 to support increased freight and ferry traffic. The project encompasses a combi-wall quay, a double-tier linkspan, a modern roll on – roll off bridge, nine marine platforms on a 290-metre jetty, and improved landside infrastructure with a new 400m access road, electrical systems, CCTV, and an asphalt yard.

Strict environmental measures are in place as no piling occurs during salmon migration (March-May), and dredging is limited to October-March to protect the river's ecosystem.

INTERVIEWEES PROFILE

The LPS implementation is confined to the main contractor as the company directly manages their own labour and any specialised subcontractors. The interviewees are profiled in table 1.

Table 1: Interviewees profiles

Interviewee	Job Title	Years in Construction	Years of experience with LPS
A	Construction Director	25	2
B	Project Manager	30	0
C	Senior Planner	32	2
D	Deputy Project Manager	20	0
E	Site Agent	12	2

Content analysis is considered most suitable because of its interpretative approach with its support for some quantification. This will be helpful in quantifying the importance of the qualitative interview and focus group findings. Content analysis is an intuitive and open approach to analysing qualitative data and can be used for hypothesis testing as well as for theory building, which also suits the chosen deductive theory building approach.

FINDINGS

INTERVIEWS

The key interview findings on the impact of the Last Planner System implementation are presented in table 2.

Table 2: Key interview findings

Theme	Key finding
Purpose	LPS was introduced to improve planning detail and better understand activity dependencies by involving multiple team members and site specialists in collaborative sessions. *"It is getting people in a room to trash out the detail and to come up with a plan that they see will work*" – Interviewee A.
Alignment	Displaying the plan to everyone and fostering discussions ensures that all package managers align their plans, reducing clashes and improving overall workflow. "*My biggest observation is the alignment we are getting to avoid clashes on both land and water as the expensive equipment must be kept productive"* – Interviewee B.
Share ownership	The process now provides greater confidence as planning responsibility is shared among the team, with regular weekly reviews and updates ensuring ongoing buy-in and clarity. "*There is a requirement for each manager to make sure the plan is well thought out because it will get looked at subjectively within the team*" – Interviewee A.
Planner's role	The Planner's role is now better supported by collective input from the team, making their task easier, though the fundamental responsibilities of the planner remain unchanged. "*They now have a forum where they can openly gather information as opposed to trying to get people to give them updates on a weekly basis*" – Interviewee A.
Continuous learning	Innovative and first-of-a-kind activities required extra time. This was highlighted and revised in the lookahead planning sessions. *"...there was a lot of new learning of how to do things like the raking piles. We learned to put in extra time for the first time so that helped give the programme more robustness*" – Interviewee C.
Visualisation	The introduction of several visual boards allowed mapping exercises to be conducted as part of the Pull and Lookahead sessions. *"Coming into the Command Room I can immediately see where we are on the project."* – Interviewee C.
Constraints Management	A dedicated constraints identification and management process focused attention on diligently removing the highest priority constraints. *"Reviewing the constraints on a daily basis and ensuring the highest priority issues are being worked on is critical for keeping the project moving forward"* – Interviewee D.
Digitisation	Using digital solutions where most impactful. *"I used a software LPS on a recent project. We used it from the start, and it was easier achieve the necessary buy-in from everyone"* – Interviewee E.

OBSERVATION DATA

Weekly PPC and RNC data was recorded and communicated back to the team. This was discussed at the next morning's huddles and reasons were addressed. PPC is presented in Figure 1. For this study, PPC is presented for project week 25 to project week 72, total of 47 weeks. However, the Lean Consultant observed and recorded compliance with white board planned targets for weeks 22, 23, and 24 and PPC averaged at 51%. LPS formally commenced on week 25 and the first formally recorded PPC was 67 percent. Over the next five weeks PPC hovered between 70 and 80 percent. For the rest of the research period, until project week 72, PPC stabilised between 80 and 90 percent, averaging 85 percent and occasionally nudging over 90 percent.

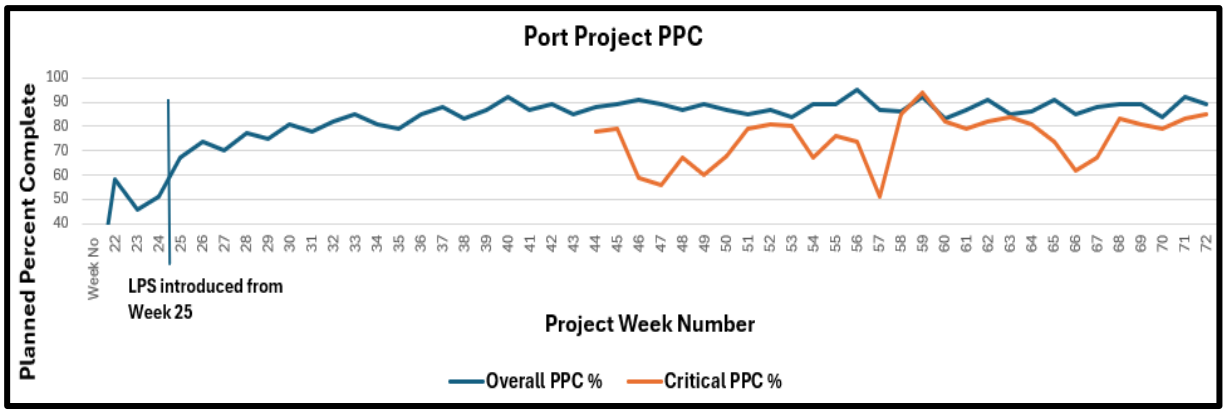


Figure 1: Port project PPC

However, over the first 20 weeks of the implementation the reported stable PPC was not aligning with schedule adherence and month-on-month the project started falling behind schedule. The team focused on highlighting the critical path and high-value tasks on both Pull Plan and Weekly Work Plan and recording a separate PPC measuring critical path PPC. This commenced on project week 48 and critical path PPC averaged 72 percent over the 25 weeks to project week 72. This data highlighted a clear disconnect or masking of true critical path performance by reporting successful completion of tasks that did not achieve near-term milestone schedule value. Critical activities PPC dropped towards 50 percent on several occasions, and this highlighted the complexity of achieving planned production on both landside and on the water. This necessitated dedicated performance improvement projects. Reasons for non-completion of tasks were recorded and reviewed weekly and are presented in Figure 2.

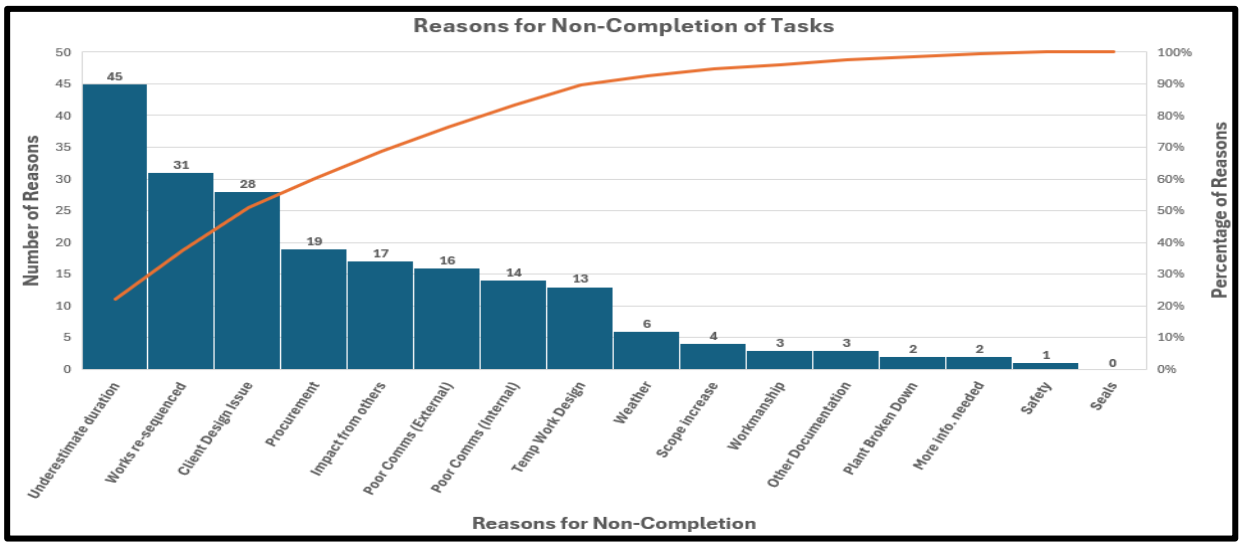


Figure 2: Reasons for non-completion of tasks

Figure 2 presents the RNC and highlights that 37 percent of missed tasks were categorised as caused by ‘underestimate duration’ and ‘works re-sequenced’ (total first two columns). Several focused high-value improvement projects were undertaken, arising from analysis of the PPC and RNC data, along with the visual impact on the Pull Plan sticky notes and the master Schedule reporting the schedule falling behind.

CONSULTANT FEEDBACK

The Lean Consultant visited the project every five weeks and suggested several interventions to the project team. The principal theme in the feedback pertained to adhering to the functions and process of LPS as advocated in the 2020 Benchmark. The Construction Director and Project Manager both referenced utilising the external consultant as a support to bring other team members back into alignment with the core process. However, a noteworthy finding emerged towards the end of the research period when the Lean Consultant visited the site after a gap of five weeks from the previous visit. During a Gemba walk to correlate onsite action with the Weekly Work Plan and Pull Plan, a disconnect in communication emerged between the Pull Plan and the onsite work. This resulted in PPC drop from weeks 63 to 67 and correlated with localised schedule slippage. Attention was refocused on creating a Weekly Work Plan with crew leaders owning the actions on the plan, and management supporting removal of any constraints. This accelerated production and recovered the schedule.

DISCUSSION

THE ROLE OF PLANNED PERCENT COMPLETE

The study proposes that using PPC alone as a measure of schedule adherence is insufficient. Only PPC from critical path items should be a true measure of schedule adherence. PPC cannot be taken at face value as an overall productivity measure because of the acute importance of the high-value activities in a port project. For example, in a particular month, if 20 activities progress as planned but the installation of piling output is less than required, then the critical project timeline has been negatively impacted, as the core purpose of the facility requires piling completion. PPC was showing over 86% weekly yet piling targets were not being achieved. Critical path PPC was measured separately from the other planned activities and showed that the critical path was only returning 62% weekly – this ensured better alignment between PPC and the CPM schedule and highlighted focus areas. The 2020 Benchmark (Ballard and Tommelein, 2021, p.3) notes '…that PPC could be 100%, productivity excellent, and a project still be falling behind schedule'. Therefore, a critical analysis of weekly PPC and RNC data is needed to ascertain actual production performance, schedule alignment, and overall risk to critical project outcomes.

USING REASONS FOR NON-COMPLETION DATA

When accurately categorised, RNC of executed tasks offer an excellent starting point for more detailed analysis to identify high-value improvement projects that enhance productivity or mitigate negative impacts. On this project, recurring missed targets for piling achievement in season 1 resulted in a widening gap between planned and actual achievement. A focused improvement project commenced with a 5-whys analysis of the poor piling performance. Optimism bias and inexperience with marine piling were the key areas identified for improvement for the remainder of season 1 and to carry into season 2. One specific improvement increased the productivity of marine piling from season 1 (June 2024 to February 2025) to season 2 (June 2025 to February 2026), increasing the average from 2.5 piles per week to 3.86 per week, a 55% increase. Another created a process map of tie-rod installation and reduced the time required for this repetitive activity by 25%.

CONSTRAINTS & VISUAL MANAGEMENT

The precast installation on the jetty was identified as an area where lost time could be recovered by more focused planning and alignment with the precast component manufacturer. A dedicated process to ensure that no design-related constraints existed enabled the precast supplier to manufacture in accordance with an accelerated schedule. The increased piling output, from the

improved productivity exercise, allowed earlier access to place the pile-caps. Precise look-ahead planning facilitated efficient and effective placement of precast beams and slabs, allowing early plant and personnel access to the jetty deck. Ensuring land-side works aligned with the timely access needed for the jetty precast placement also necessitated specific, focused Lookahead Planning workshops to challenge optimism bias by agreeing on realistic, achievable productivity metrics.

The literature highlights the identification and timely resolution of constraints as a vital element of effective Make-ready Planning that contributes to a smooth workflow and effective project performance (Power et al., 2024). A valuable outcome identified in this study was the importance of the constraints process. Several interviewees referred to the formality of identifying and logging constraints, having a routine for resolving constraints, and focusing on the highest priorities. The Port project encouraged highlighting constraints whenever possible. Each morning Huddle addressed the constraints board, and only the highest priority constraints were referenced. The Client's representative attended the morning Huddles and was most interested in which highest-priority constraint the Client should be working on, or in reinforcing its importance to a particular design team. Figure 3 presents the Constraints Log board, and Figure 4 shows the screening mechanism used to ensure each task was 'ready' to be committed to the Weekly Work Plan.

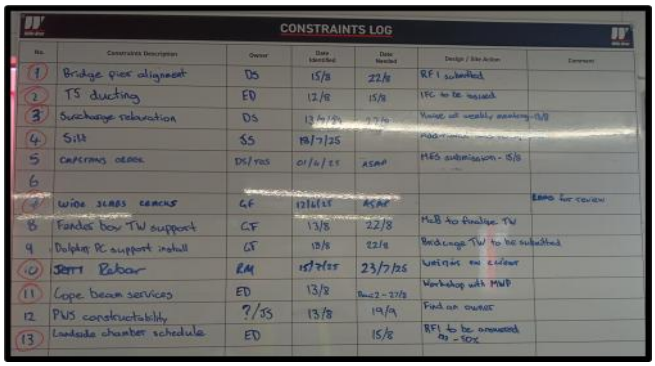


Figure 3: Constraints log

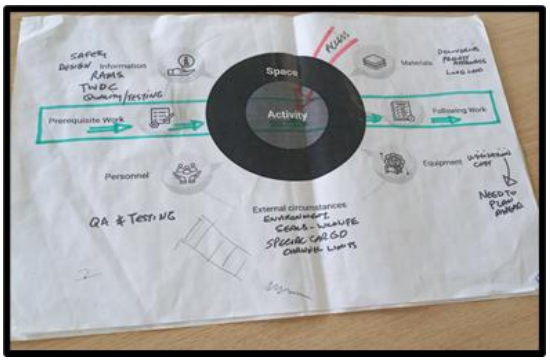


Figure 4: Screening for 8 flows

The implementation of digital solutions to facilitate Lookahead planning enabled Site Agents to leverage the 4D Coordinated model for the simulation of alternative sequences and the resolution of coordination challenges. Synchro 4D's functionality to compare programme versions concurrently eliminated speculative planning and promoted informed decision-making. Clash detection proved especially beneficial in managing marine plant operations as the software identified overlapping barge assignments, enabling planners to adjust schedules and prevent onsite conflicts. This predictive simulation capability contributed to reducing the risk of plant clashes and optimising resource utilisation. When jetty extended further out and the project became entirely water-based, the lookahead planning process relied heavily on simulation of barge movements to enact First Run Studies for the upcoming four weeks.

USING ALL FUNCTIONS OF LPS

Senior management noted the importance of having a routine and process for planning and executing the project. The Construction Director had witnessed Weekly Work Planning used on a previous Pharma project. The Senior Planner had used the '3 C's' (Concern, Cause, Countermeasure) as part of Collaborative Planning on Highways projects in the UK. Others had previously seen Daily Huddles or Whiteboards. However, none were exposed to the complete system of using all functions of LPS. Literature asserts LPS works best when all functions work in unison (Ballard and Tommelein, 2021), with the Benchmark (p.6) noting '…Omission of a part destroys the system's ability to accomplish its functions.' Figure 5 shows the 12-week Pull

Plan, which is organised in workstream swim-lanes with interfaces and handoff points highlighted. The Master Schedule milestones are the red diagonal stickies on top of the board, which are the basis of the 'Pull.' The Senior Planner places the Milestones on the board, and the Site Agents and their teams conduct their monthly Pull Planning sessions to populate greater detail on the board. Weekly Lookahead and Make-ready sessions are conducted each Monday. A weekly coordination meeting is held every Thursday where the Site Agents present their Weekly Work Plans and is attended by the Senior Planner and Project Manager. The agreed Weekly Work Plan then becomes the focus of the Daily Huddles held each morning at 8am. RNC is recorded daily, and every Monday, PPC and RNC are communicated to all team members. Senior management can then address any trending risks or issues.



Figure 5: 12-week pull plan boards.

ROLES OF TEAM MEMBERS & CHAMPIONS

The Construction Director, Senior Planner and Site Management team received detailed training on LC and on the functions of LPS prior to implementation. This education formed the foundation for a better understanding of the 'how' and 'why' LPS was being introduced to the project. This also ensured better ownership and compliance with the weekly routine that was implemented. Additionally, this accountability also cascaded to the team members who were executing the work. Again, the literature is clear on the importance of training and educating project teams as Daniel and Pasquire (2017, p.1) propose '…an organisational level requirement of commitment to training and retraining of team to achieve the required competence, continuous development and coaching of the team.' Identifying and dedicating effort to mentoring and coaching Champions of the process implementation has previously been identified as a critical enabler of success (Thomassen et al., 2003; Daniel and Pasquire, 2017; Ebbs et al., 2018). This Port study highlighted the importance of early investment in education and ongoing coaching and facilitation as being critical enablers of successful implementation. The Site Agents became the Champions, and they noted that ongoing external support gave them renewed confidence and added focus in their running of the Lookahead Planning sessions and Daily Huddles.

UNIQUE CHALLENGE OF PORT PROJECTS

A unique challenge relating to a Port project is managing the interface between land-based and water-based works. Both locations have their own critical paths to completion, but significant handoffs existed towards releasing access onto the new jetty facility. This access is , inessential to linear facilities like jetties, where cost savings can be achieved by getting craneage and concrete pumps on the permanent platform as early as possible and releasing expensive barges for specific water-based activities. LPS and its functions enabled the deep planning sessions to plan and organise towards these critical handoffs. Learning from previous missed tasks

tightened the process, minimised optimism bias, and contributed to greater adherence to task execution.

Another specific challenge in large-scale port projects is accessing the competency and tacit knowledge to execute the project. Port projects of this size are rare in Ireland, and this was the contractors first Port or Marine project. Again, LPS and the routine created around Lookahead and Pull Planning facilitated the discussions where team members could anticipate most challenges and had time to address constraints that would otherwise have emerged at the point of work.

Every LPS implementation experiences challenges in the initial stages. The interview and observation findings noted that the early education and ongoing facilitation made the implementation much smoother. Adhering to the new daily and weekly routine took time initially, but after early success, it became easier to achieve broader buy-in to the process. Senior leadership support and presence subconsciously mandated compliance with session and Huddle attendance.

Looking ahead over 12 weeks was challenging, and some thought it might have been unnecessary. However, when constraints were identified far in advance, it became clear that having external teams remove these impediments resulted in much less stress on the site teams closer to execution time. The team noted the extra workload and effort required to consistently chase down the resolution of open constraints. However, the results far outweighed the effort as creating a precise flow of ready tasks for execution was critical to recovering the schedule and achieving success.

LESSONS AND INSIGHTS FROM THE IMPLEMENTATION OF LPS ON THE PORT PROJECT

All functions of the LPS are essential not only for executing the project but also for ensuring effective management at every level. The significance of connecting planning activities with crew-level input cannot be overstated, as it brings those directly involved in the work into the process and leverages the experience and expertise of drivers and operatives. This direct engagement with the workforce supports the utilisation of practical knowledge that is often pivotal for addressing challenges on site.

A deliberate decision was made not to rush into digitising the LPS process before it was thoroughly refined and understood by all stakeholders. By allowing the process to mature before introducing digital tools, resistance to change was reduced, and collective problem-solving was strengthened. This approach allowed the project team to manage uncertainties—such as temporary works, evolving designs, tidal conditions, variable weather, and unexpected geotechnical issues—without adding complexity through innovative technology. By prioritising the development of clear routines and a collective understanding of LPS principles, the team laid a solid foundation for any future digital enhancements.

Establishing a culture that prioritises open communication and feedback loops at all levels proved invaluable. Such an environment empowered team members to respond proactively to changing site conditions and to adjust plans as necessary. Regular engagement and collaboration between management, site teams, and operatives ensured that insights from those working “at the coalface” were incorporated into planning decisions. This approach produced robust and resilient project outcomes.

CONCLUSION AND RECOMMENDATIONS

This study’s objective is to evaluate how LPS was implemented and to determine the challenges and benefits of using LPS on the selected maritime port project. The study found that challenges included the uniqueness of the Port project and maintaining the team’s diligent focus on

adherence to the process. Findings highlight productivity and schedule-alignment opportunities arising from a collaborative planning routine and cycle in the Last Planner System application.

Building on the lessons learned, it is recommended that PPC focuses on tasks directly affecting the critical path, ensuring that effort is channelled where it will have the most significant impact on project delivery. The complete implementation of all LPS functions is essential, supported by comprehensive training to foster understanding and consistency throughout the team. Implementing a diligent constraints process that proactively anticipates obstacles and manages a resolution process is essential for creating a transparent workflow. The presence of a dedicated Lean coach, coupled with ongoing facilitation, is crucial for embedding Lean and LPS principles, maintaining the implementation of all LPS functions, and supporting continuous improvement, thereby sustaining effective collaboration and better project outcomes. A limitation of the study is that the interviewees are all from the same contractor. As the purpose of the interviews is to elicit information on the impact of the LPS implementation, it was considered appropriate. Future research should incorporate more use of BIM and Digital Twins, expanding the current 4D simulation in parallel with the LPS implementation.

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