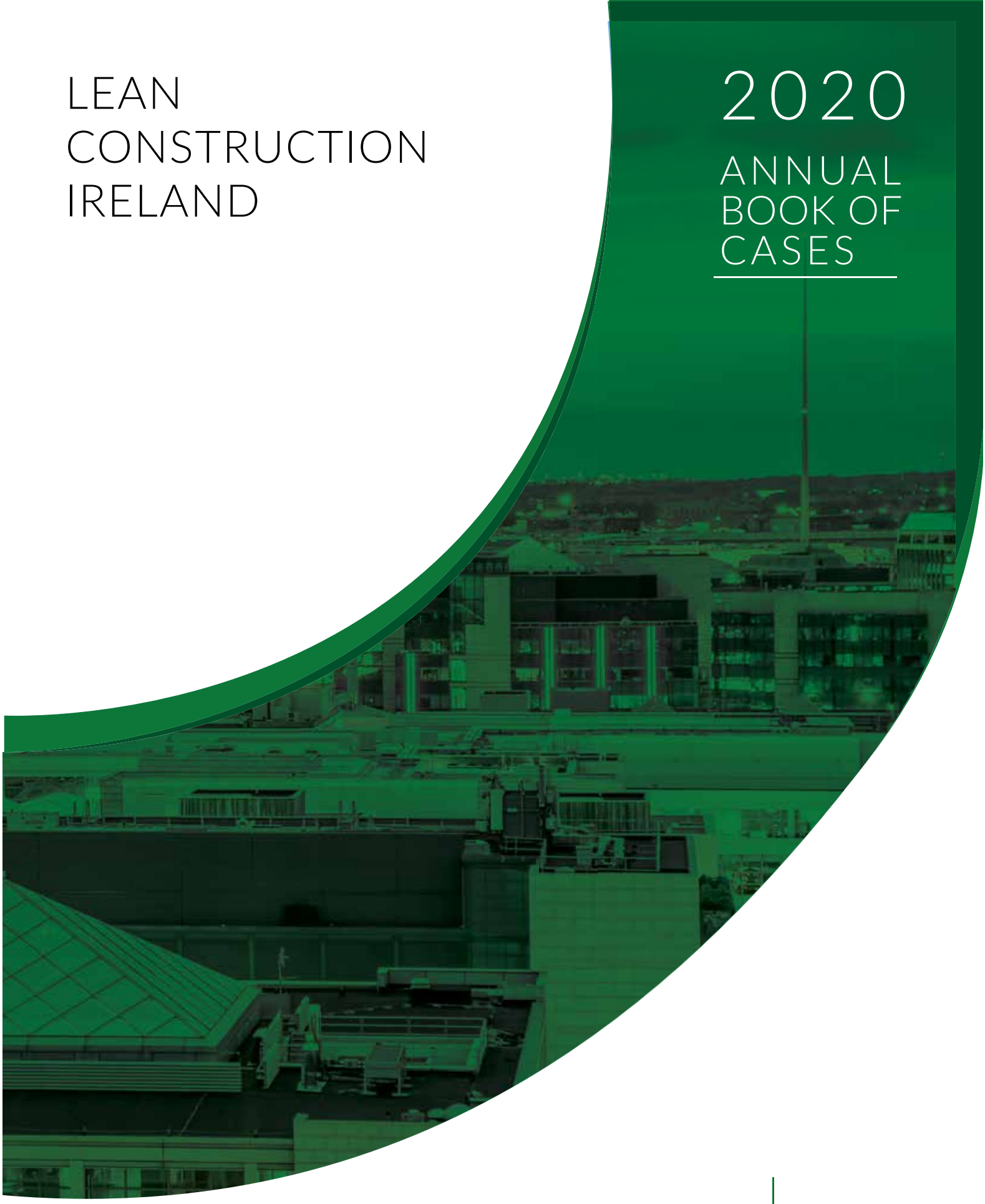
LEAN CONSTRUCTION IRELAND

2020 ANNUAL BOOK OF CASES



Benson Building
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Editor

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Waterford Institute of Technolog
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Darrin is a Lecturer in Management at Waterford Institute of Technology (WIT) School of Business. He is Joint Programme Director of the WIT Lean Enterprise and Operational Excellence portfolio of executive/practitioner programmes; a Faculty Member of the WIT RIKON Centre; and Principal Lead of the WIT Academy of Lean Enterprise Excellence.

Prior to entering academia, Darrin worked for over a decade in the private sector as an operations manager as well as in consultancy. He joined WIT in 2004, and lectures Lean and Operational Excellence modules on several executive/practitioner programmes, including: the Master of Business Studies in Lean Enterprise Excellence, the Diploma in Lean Fundamentals (Online), the Diploma in Supervisory Practice, the Executive MBA, and the Master of Science in Construction Project Management. He supervises postgraduate research on Lean management, operational excellence, continuous improvement, and Lean construction. Additionally, Darrin coordinates the Annual WIT Lean Enterprise Excellence Forum and the Annual WIT Lean Practitioner Seminar Series – hugely popular national and regional knowledge-exchange events built on extensive Industry-Academia-State engagement and collaboration.

Darrin continues to work extensively with industry, encompassing public and private organisations across all services and manufacturing sectors. He is a founding member of Lean Business Ireland, he is Co-Chair of the South East Lean Network, and he assisted in the establishment of the other Regional Lean Networks throughout Ireland. Darrin has worked with Lean Construction Ireland (LCi) since 2015 where he acts as Special Advisor to the LCi Board of Directors as well as Lead of the LCi Capability Development pillar. Darrin speaks at Lean and Operational Excellence conferences and events, and researches and publishes in the Lean space, including case books on Lean commissioned by LCi and Enterprise Ireland.

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Foreword

Richard Fitzpatrick
Chairperson of Lean Construction Ireland

On behalf of the Board of Lean Construction Ireland (LCi), it is my great pleasure to welcome you to the third publication of the Lean Construction Ireland Annual Book of Cases – the key Lean Construction reference publication for the Irish construction sector, from Clients and Owners to Professional Services Consultants, Contractors, Sub-Contractors, and Suppliers.

This third Book of Cases clearly demonstrates that the Irish construction sector is making significant progress in understanding and implementing Lean thinking and practices on capital project delivery as well as for internal organisational transformation, adding real value for all project stakeholders and business owners. The publication of our Book of Cases continues to reaffirm the LCi principle that the open exchange of knowledge, information, and experiences around good Lean practices is a fundamental factor in the sector's adoption of Lean, and I thank all the case contributors for their collaboration and generosity in sharing their Lean journeys with the wider Irish construction sector.

This year has been a year like no other, dominated by Covid-19 which has changed the way we live our lives, how we work, and how engage with our work colleagues and project delivery partners. The Irish construction sector has responded positively to the impact and challenge of Covid-19 by adapting the way projects are delivered to safeguard the wellbeing of all involved whilst ensuring client and project objectives are maintained.

Covid-19 has accelerated the need for change, requiring the sector to build on the journey of change it has been on over the last number of years, including, for example, Lean, Digital Technologies, and Off-Site Production, and this current environment affirms all the more the need for the sector to fully embrace and implement Lean thinking and practices. With our Book of Cases 2020, along with our Annual Conference, monthly Webinars, and other information freely available on our website, LCi is uniquely placed as the lead advocate for Lean in Ireland to support the Irish construction sector on this journey of transformation.

I would like to take this opportunity to acknowledge all involved in the publication of Lean Construction Ireland Annual Book of Cases 2020, the organisations that have contributed cases, the organisations that have sponsored the book, and our publishing partner Box Media. Finally, I would like to thank Darrin Taylor from Waterford Institute of Technology for his invaluable input as Editor in coordinating and compiling this invaluable publication for Lean Construction Ireland.

I hope this third Book of Cases from LCi continues to inspire you and your organisations to adopt Lean thinking and practices and to continue to work collaboratively to deliver projects better, faster, together.

Sincerely,

Richard Fitzpatrick
Chairperson, Lean Construction Ireland

5 Hanover Quay
Image Courtesy of Linesight

CHAPTER 1

Case Studies

Company Overview | Mace | mace.ie

Mace Technology Ireland (Mace) has been established in Ireland for over 10 years and has constructed two of Ireland's largest and most prestigious projects, namely Dublin Airport Terminal 2 and Project Cln, a hyper-scale data centre campus in Clonee, Co Meath.

Mace operates not only as a general contractor here in Ireland, but also provides professional construction services such as cost management and programme management for blue-chip clients such as Microsoft, Irish Water, Citrix, and Invesco.

Author

Kevin McHugh

Overview & Background to the Lean Initiative

The Digital Control Room

Mace deploy a collaborative approach to manage the programme and production control management system. Mace has learned that Visual Management (VM) tools are key to identify and focus on critical areas to manage risks and opportunities in production control.

VM is identified as an important tool to develop a high-performance multi-disciplined team. To assist the forming of the team, a "Big Room" environment was developed to allow teams to communicate and collaborate effectively, to develop a learning work environment,and to build trust and promote transparency between teams.

Figure 1. Lean Construction Principles

Lean Initiative Undertaken – Lean Thinking, Tools, Techniques

The control room allowed multi-disciplined teams to communicate and collaborate so as to better manage project risks and identify opportunities for project improvements. This approach broke down barriers and allowed teams to integrate and identify areas to focus on collectively. The control room dashboard meeting was a structured meeting where in package information was formatted and presented similarly across all packages. The information was displayed on a series of magnetic whiteboards with marked-up drawings and pdf worksheets to show the current state of the packages. Here, package information could be presented and interrogated in a collaborative fashion.

However, as the teams became more disciplined, it became apparent that the volume of data that was being collected on the project could not be displayed and updated efficiently in the room. As a result, it was difficult to effectively manage a hyper-scale data centre using analogue tools.Therefore, a digital collaboration control room was developed.

Figure 2. Digital Control Room

Optimise the Whole

Respect for People is the cornerstone of Lean thinking as people transform ideas and materials into final useful value. Respecting the contribution of each individual is necessary to tap this resource. In addition, people are central to the success of Lean project delivery, and the production management-based approach of Lean project delivery encourages all efforts to make transparent and then optimise all processes and flows within design and construction work.

Visual Management

VM is applied as a holistic system supporting the visualisation of information to help teams and individuals to gain a better understanding of their role and contribution within the larger frame of a project.

The control room is a dedicated co-location space developed to create a transparent and open environment for people to communicate effectively. VM is a key component of the room as people are usually attracted by what they see. The objective is to use visual aids to make communication simple and attractive. Correct representation of information can help mitigate the complexity of production systems, even in chaotic and unpredictable production environments. Among the benefits of VM are that it directly supports other management functions, such as production management, safety management, performance management, and workplace management, allowing optimisation of the process and work flows.

In addition, the use of VM tools improves our ability to process information and reduces feedback time for action taking, such that control can be integrated into execution. A digital platform allows virtual tools to be introduced to improve the transparency of planning and to act as an aid for collaborative use in planning and control meetings. Their other benefits include greater discipline in the workplace, continuous improvement, and work facilitation.

Figure 3. Collaborative Meeting

Removal of Waste

Waste can be defined as any task that does not add value. Value-added tasks are tasks that meet the following three criteria:

- Meets end customer needs.
- The task changes the shape or form of a product or service.
- Executed right the first time.

The ability to identify and remove wastes from all production is a key facet of a Lean production system. Studies have shown that approximately 70% of the activities performed in the design and construction industry are non-value-add ("waste").

The volume of the data processed on the project, and the use of digital field tools to track safety quality, commercial, and programme activities, required a more agile VM solution. In parallel with the improved production control meetings, it was clear that the weekly package dashboard meetings also needed improvement.

There were large volumes of issues which were not managed efficiently due to the diverse range of information required to present at the package dashboards. All this information was available digitally and was downloaded and printed to make up the composition of the dashboards. This proved inefficient and often included information that was not the latest available information for the review.

Project Manager time was ineffectively used to gather and present the content for the whiteboards. The volume of information made it difficult to process in the meeting. There was a number of meetings required between each discipline working on a package to collate and present the package KPIs. The information was gathered and presented by each package where it was difficult to present the whole project risks and opportunities. This resulted in critical information that was not presented or updated.

Overall, this represented substantial waste in our production control system. The collected information was not sufficiently integrated, which hampered making identification of multi-disciplined dependencies visible. This also raised issues for wasted project improvement opportunities. To increase agility and respond rapidly to unexpected problems, it was essential to shorten the communication time between workers and decision-makers.

A digital control room was identified to replace whiteboards in the Big Room meeting. This allowed for collaborative dashboards to be produced and presented digitally. The information displayed was live current package information covering all KPIs for the package. This also did not take away from the VM standard to view the entire project status at a glance. Here all project information could be presented clearly and all stakeholders could identify make-ready-needs. This improved the flow of information as critical information could be actioned in a timelier manner.

All information is sourced from a central database, and this eliminated the waste of replicating the works to display on the whiteboards. The number of meetings required to prepare the package dashboards was reduced. The effectiveness of the collaborative meetings improved to the point that all packages could be reviewed in the allotted meeting time.

Figure 4. Control Room Dashboards

Process and Flow

Information was formatted and displayed where the current state was easily visible. This structure allowed for presented material to be interrogated and referenced to provide project clarity. This allowed the senior leadership team to make informed decisions to progress the project effectively by mitigating risks and maximising opportunities.

The importance of making tasks ready cannot be understated in managing flow. The ability of multi-disciplined teams to work in a form where a rich source of digital information is displayed and can be interacted with.

As construction projects are large and complex, the current state is not obvious. Improving the ability of project teams to react and manage projects in an agile fashion increases the project team's overall effectiveness to manage complex construction projects.

As modern construction projects consist of multinational stakeholders, including clients, design houses, and specialist trade contractors, using a co-location model is not always practicable and can be logistically difficult to sustain. Using a digital format allows for remote collaboration and maintains a creative link between remotely working teams.

Lean Initiative Improvements & Impact

Generation of Value

Working with a greater volume of information that was presented in a usable way provided greater clarity and allowed all stakeholders to identify and evaluate opportunities for improvement internally whilst also identifying make-ready-needs associated with upcoming tasks. As principal contractors, Mace was able to use this information to provide direction to its trade contractors and increase the productivity of all site operations.

Weekly meetings were reduced in length and delivered increased productivity. This increased the volume of information that could be interrogated at the dashboard meetings, standardised the information displayed, and increased the quality of the information displayed. This allowed areas to be managed in greater detail and improved inputs and outputs from the collaborative meetings.

With the larger weekly volume of activities being identified and made-ready, a more efficient system was required to manage weekly work plans and short-term look-ahead plans. We decided to digitise the system fully and use a cloud-based collaborative platform on which we could display a larger volume of tasks.

This led to the introduction of cloud-based software, developed on the project, to manage the LPS. This allowed the team to upload and co-ordinate their 6-week look-aheads to one platform. This in turn provided greater transparency of look-aheads that allowed contractors to be more informed when creating their weekly work plans. The digital wall was used in collaborative weekly work plan meetings where multiple displays could provide models, plans, programmes, and weekly work plans to improve collaboration at the weekly work plan meetings.

Using a digital platform put more emphasis on packages preparing look-ahead plans and identifying make-ready-needs to improve the accuracy of weekly work plans. Using a digital collaborative platform also improved the quality of the actual weekly work plan review meeting as a greater volume of tasks could be reviewed efficiently. This dramatically affected the quality and quantity of weekly planned committed tasks.

With this increased information, the quality of weekly work planning meeting improved. There was a shift from the silo mentality of producing a work plan and look-ahead plan in isolation solely focusing on a package rather than a project progress. With greater transparency, a more informed look-ahead plan could be produced for review collectively.

Figure 5. Control Room Digital Collaboration

This allowed packages to work as a team to identify risks and opportunities to the current site production. Constraints that were outside the control of the package manager level could more effectively be communicated to senior management to provide direction and mitigate if necessary. The greater transparency allowed teams to articulate issues effectively, which provided an opportunity for all project stakeholders to effectively communicate and react to live project conditions.

The result was an efficient weekly production system that could provide predictability and reliability to the project progress. The efficiencies from work crews provided opportunities for increased off-site manufacturing plans because of the reliable delivery of construction activities.

This allowed teams to forecast resources effectively and ensure specialist contractors were available when tasks became ready.

Continuous Improvement

Continuous improvement ("Kaizen") is a highly dynamic capability that can be viewed as an organisation-wide process of focused and sustained incremental innovation. VM serves as a basis for continuous improvement, and perhaps more importantly stimulates employee involvement to manage and improve safety and quality.

The use of digital dashboards provided a rich source of information. This allowed a more agile approach to construction management. Teams presented tasks in progress and planned works in a controlled and organised manner. The integration of the make-ready process and the utilisation of the Big Room environment allowed management to share project updates and to focus on upcoming challenges. The ability to utilise the huge amount of digital information to capture the project KPIs allowed for a smooth and informed project delivery method.

This inclusive environment strengthened the Lean culture in the team. Digitisation of the project management system provided a leaner and more inclusive platform for the team to utilise. This in turn allowed for greater stakeholder collaboration with the shared information providing a single source of truth.

The initiative to use a digital wall greatly increases our ability to prepare for collaborative meetings, and it has greatly improved the quality and efficiency of team meetings. This allows teams to challenge each other and to continuously improve throughout a project. As a result, teams are now able to focus on opportunities for improvement and to develop quickly and effectively into high-performing construction teams that deliver greater value-add for our clients and for our supply chain partners.

Company Overview | DPS | dpsgroupglobal.com

DPS Group is a global consulting, engineering, and construction management company serving high-tech industries around the world. DPS has sector experts in key locations in Europe, USA, Asia, and the Middle East, bringing world-class resources and the latest innovative technologies to every project. DPS delivers full-service Engineering with a 'client first' mentality and personal touch across a range of disciplines: Project and Programme Management, Procurement, Design, Construction Management, Health & Safety Management,Commissioning, Qualification, and Start-up. DPS employ more than 1,850 people worldwide, including 300 in its Cork operations where this case study is based.

Authors

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Overview & Background to the Lean Initiative

DPS Group

The company modestly prides itself as being an early adopter of Lean thinking and practices in both Irish and International construction sectors. The company invests heavily in staff subject matter experts, in Lean education and training, and in internal process improvement initiatives. DPS Group has previous case studies on Last Planner® System and Target Value Design published in the 2018 and 2019 LCi Annual Book of Cases respectively. As teams become more familiar with tools like LPS, further improvement opportunities become apparent and encourage innovative solutions. One such case is the application of Takt planning to complement existing LPS implementation. A member of the DPS team had attended a client training session on Takt implementation for use on another client project, and subsequently DPS decided to trial and experiment with Takt on one of its own construction projects. This case study presents the challenges and learnings gleaned from the latter pilot implementation.

Lean Initiative Undertaken – Lean Thinking, Tools, Techniques

Overview

Takt is the German word for beat – the regularity with which something gets done. Takt encompasses core concepts of Lean, but is rarely witnessed in traditional construction planning. It aims to break the construction process down into smaller work tasks of equal duration that can be completed at a steady rhythm, and which leads to greater predictability in the planning and delivery process. Takt planning introduces the concept of the assembly line, rooted in manufacturing (especially automobile assembly lines), into construction processes. This model makes Takt particularly useful when repetitive tasks exist in the construction process. Whilst the Phase and Look-ahead functions of LPS break the tasks into finer levels of granularity, Takt can complement the planning process by forcing consideration of space and time, and capacity (crew sizes). This trial of Takt focused on complementing the Phase and Look-ahead functions of LPS.

The Project

The case project is a 4,000m2 warehouse at a pharmaceutical manufacturing facility incorporating high-level racking, clean room storage, goods reception, dispatch area, office, canteen, locker room, and welfare facilities. It is a stand-alone building with varying spatial areas and, at first glance, little suitability by way of repetition for an effective Takt implementation. However, DPS Production Planners considered elements of Takt would lead to deeper analysis of task planning and would contribute to better prepared Weekly Work Plans (WWPs) in LPS.

Takt Methodology

The Takt methodology employed was adapted from Use of Takt Planning in Production System Design Workshop on Takt Planning by Patrick Theis (Drees & Sommer), Iris Tommelein (University of California, Berkeley), and Samir Emdanat (vPlanner) at UC Berkeley on 26-27 September 2017.

The main steps taken were:

1 Overall Process Analysis (OPA) – This is an analysis completed at the LPS phase pull planning stage that aims to identify the different work areas (zone types) that correspond to construction phases. The analysis also looks to define the process steps and sequence of trades within the zone types. The OPA is conducted by dividing the building into areas that have the same process sequence. In this case study, six zones were identified that specifically related to the following trades' first-fix works: Mechanical, Electrical, HVAC, and Sprinkler. Process steps for each trade were mapped for each zone and planners focused on breaking down steps to create as much repetition as possible. Like the manufacturing process, the idea is to minimise variation that would impact smooth flow.

Figure 1 illustrates a preliminary mapping exercise to establish the sequence of tasks and to validate the logic of the master schedule prior to dividing the floor area into work zones.

Figure 1.
Schedule Duration and Logic Validation Exercise

2 Takt Analysis (TA) – The TA is based on the outcomes from the OPA results. During this step, the team considers the amount of work and the appropriate Takt time for the sequence per zone type. This is where the greatest challenges were encountered as detailed quantities of process and drainage pipelines, primary and secondary plumbing lines, ducting runs and bracketry, cable trays and number of cable pulls needed to be compiled per defined work zone. Figure 2 presents the sequencing and crew sizing for the first Takt run of 2.5 days and the second run of 5 days per zone.

Figure 2.
Standard Process Steps & Crew Sizing

As a planning exercise, this was beneficial in visualising the scope and scale of the works to be completed in each zone. However, the trade supervisors deemed the work cumbersome as they were more comfortable dealing with issues and conflicts as they arose. When allocating quantities of work to be executed against available space – the pre-defined work zone – the planners were able to start generating optimum crew sizes whilst identifying which crews required time in each zone. The idea is to establish a suitable Takt time that can work for all trades in all zones. We found that some trades may have their work complete in less than the Takt time, and therefore a backlog of available work (outside the Takt zones) is needed to utilise the crews. On the other hand, larger crew sizes than the trade supervisor would have preferred may be necessary to ensure that the requisite works are completed within the Takt time. In an ideal application, the client may offer to financially supplement the extra resources or equipment needed to keep production within the Takt time. In our application, we strived to break down the task into smaller batches so that instead of having a three-person crew that needed to be four persons, we split the tasks to enable multiple smaller crews (two persons) to move more productively through the work zones. This concept is described as a "Takt Train".

3 Applying Takt Planning to Organise the Phase Schedules – This is the step where the pre-planning work is collated to develop the Takt phase schedule. The planning team has defined how the Takt Train will be moving through the building, how many Takt zones will be handled at the same time, and what dependencies between the zones must be considered. The phase selected on this project was specifically for the first-fix installation, and it is important to note that separate Takt planning exercises should be conducted for separate phases of the project, including for example, second-fix, fit-out phase, and the commissioning and handover phase. The progression of trades through the zones is viewed as one trade in each wagon that stops in each zone for the agreed Takt time period. For example, on this pilot we simplified the durations into 2.5 days for the hangers and brackets install, and 5 days for the first-fix install. With tight daily management of zones and crew performance, it is possible to create smooth reliable flow with no idle time. The Takt plan is shown in Figure 3.

Figure 3.
Warehouse Takt Time Plan

Lean Initiative Improvements & Impact

We acknowledge that there is much ongoing action research into Takt application in construction, and note that this pilot implementation was primarily concerned with the DPS Production Planning team and the trade supervisors learning about the potential offered by Takt planning.

The study contributed towards improved coordination of trades on-site, and confirmed that Takt and LPS complement one another. Takt and OPA demand a much deeper analysis than our traditional Pull Planning sessions were achieving. Considering space as both a constraint and an input to the production process generated greater appreciation of the importance of when a trade obtains possession of dedicated space and when it must pass that space onto the following trade. The process of sizing each task (based on quantity to be produced, for example, metres of cable tray to be fitted or number of ducting hangers to be erected) along with developing a regularity around time, and aligning this with space and optimal crew size, forced a deep analysis of the step-by-step building construction process. In turn, this exposed many conflicting issues which traditionally would be deferred and ultimately crisis-managed when it came to execution of the work. Interestingly, greater emphasis was placed on getting work ready to perform – the consequence of not getting in and out of a zone on time would cause detrimental impact to following trades. Despite the obvious benefits that would become apparent from a rigid and structured Takt application, we found that major obstacles exist within current delivery models that would inhibit a more complete implementation, including:

- If required, financial compensation must be in place to enable crews work "inefficiently". For example, a usual two-person crew may need to be increased to a three-person crew for a duration. While appearing to contradict some principles of Lean thinking, this under-utilisation may be required to ensure reliability of the Takt plan.
- Resources must be readily available to replace crew members who do not turn up on the day, either through sickness or other absence. Trade commitment is critical as the Takt Train must keep moving as the entire process is adversely affected by absenteeism or reduced crew size. Buffers may be created within the plan, for example, extended working hours or Saturday work (financial compensation may be necessary), but ideally these buffers should be held in reserve for reasons other than resource unavailability.
- Lean education is an essential pre-requisite. Understanding concepts like small batch production, reliable-promises, right-first-time, 5S, SMED (applied to ensure consistent preparedness to execute the task), and PDCA are all key ingredients for successful task execution.
- Behavioural and mindset change is required for those who are unfamiliar with the level of micro-planning expected.

The positive learnings from the implementation are as follows:

- The detailed micro-planning required by the OPA and TA stages contributes to greater success on the WWP. The increased preparedness of work tasks being committed to the WWP contributes to better PPC, and results in less firefighting and crisis-management. Activities of the correct size and sequence are provided to the Production Planner as well as a clear outlook on upcoming work.
- The concept of small batches of work assigned in the Takt-time cycle permits tighter crew planning and management.
- A mature LPS implementation and trades experienced in LPS are desirable prerequisites to introduction of Takt.
- Return to work start-up post-COVID was able to utilise Takt concepts to enable social distancing in trade coordination.
- The challenges encountered are now a good starting point for the impending Takt implementation on the current on-site project.

Summary

As an overall summary, we were ambitious with the undertaking given that the construction process was non-repetitive in nature, and, whilst the first three weeks stayed on track, as soon as cumulative issues started impacting the plan, crews started to fall back into traditional crisis management. The Production Planners continued adjusting the Takt plan to accommodate change, but the discipline and trust to stick with the plan faded. The sight of floor space lying idle as some crews finished early was too tempting for both site and trade management; the urge to fast-track certain zones meant a movement away from the master Takt plan.

However, the detailed planning was a success and the OPA approach continued to add positively to the WWPs – the intense focus on reduction of variability and minimisation of potential disruptors to workflow is a prerequisite for Takt. Therefore, LPS and Takt should complement each other at early stages of an implementation. The concept behind Takt assisted the post-COVID lockdown start-up planning, and both client and senior management are now committed to developing Takt concepts and increasing LPS and Takt alignment.

Company Overview | Jones Engineering Group | joneseng.com

Jones Engineering

Jones Engineering Group is a leading global, mechanical, electrical, and fire protection contractor operating in 14 countries across Europe and the Middle East. The original company was set up by Harry O'Neil in 1890 and, to this day, it has continued his vision of prioritising education, training, and innovation.

Over the last century, Jones Engineering has grown sustainably in both size and reputation, with a turnover of approx. €700m and personnel of over 3,500 people worldwide.

Jones Engineering has been applying Lean principles for many years, and recognising the benefits it brings to the firm, our, clients and the industry as a whole. This commitment has fostered our dynamic, knowledge-driven, and customer-focused concentration on creating value-add and eliminating waste.

Authors

Niall O'Donnell

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Overview & Background to the Lean Initiative

Jones Engineering Services provide engineering maintenance services to our clients throughout Ireland. We offer a single source maintenance and asset care solution for facilities, covering all aspects of mechanical, electrical, fire protection, heavy lifting, and instrumentation across all sectors utilising a Computerised Maintenance Management Solution (CMMS) with a 24-hour helpdesk for more than 500 clients.

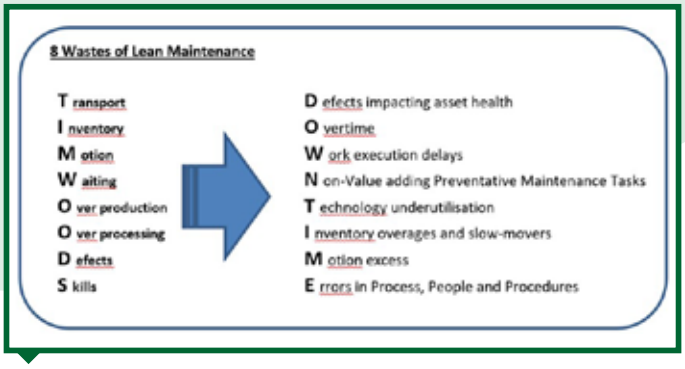

Figure 1.
Jones Engineering Maintenance Services approach to Lean Waste Analysis

Our intention is to remain at the forefront of our industry by providing quality service within schedule and budgetary constraints, developing innovative systems and strategies for the future, and continuing to build upon the engineering and technical excellence which has long been associated with Jones Engineering.

With a large operation in a dynamic environment, flexibility in management and availability of resources is necessary for the delivery of maintenance services to customers with as little waste as possible.

At Jones Engineering, we recognise that the key behind Lean thinking is that service/maintenance department processes and client requirements are inseparable and complement each other to sustain the competitive edge of any organisation. To identify ways of improving the production process, we identified the 8 wastes of Lean Maintenance and Reliability and streamlined our CMMS system.

This eliminates processes that do not add value to the customer, inefficiencies in processes, and variations in the pace of services.

Lean Initiative Undertaken – Lean Thinking, Tools, Techniques

To incorporate Lean Maintenance techniques into Jones Engineering Services activity, a strategic approach to all processes was required to provide a more efficient service to our clients. We provide a streamlined solution to our partners in critical environments with unpredictable demands. Our daily challenge is to seamlessly juggle resources to suit fast-changing scenarios across a nationwide operation base, servicing Planned Preventative Maintenance (PPM), Reactive call-outs, and Minor works projects.

Meeting and demonstrating service level agreements (SLAs) to guarantee our clients' critical plant operations is managed through our CMMS. Each client site requires particular skillsets, with varying asset types from newly installed to end-of-life and beyond. Each client has different operational procedures and conditions that must be adhered to.

It was recognised that the CMMS knowledge available was required to flow to all levels of the process to eliminate any flaws in our procedures. Cutting out non-value-added tasks has given us a competitive edge and decreased engineering maintenance costs for our clients. We provide the service and assurance our clients require, that their plant is operating at its peak performance, saving on operating costs and downtime to their facility whilst guaranteeing compliance with standards.

The backbone of our service is our CMMS tailored to manage and record the flow of information from initial calls right through to asset reporting and analysis. This is available at a client's fingertips, eliminating historical practices when issuing folders and folders of paper reports was the norm.

Lean Methodology

Applying the DMAIC (Define, Measure, Analyse, Improve, Control) methodology to analyse the processes involved on the CMMS is an effective method when applied to the process that designs or builds the product rather than looking at the product itself.

The define stage of DMAIC highlighted opportunities for improvement, current problems and the main aims and objectives of the process. It was defined that external inputs to the autonomous system were decreasing the output of each stage in the maintenance system, defined as the 8 wastes of Lean Maintenance ("DOWNTIME") affecting productivity and creating delays in the system flow.

The goal was to increase productivity by 10% within a calendar year.

Notable waste areas identified were:

- Time lost waiting for quotations and approval.
- Time lost to technician familiarity of previous asset history.
- Mis-directed calls – identifying operational issues.
- Call logging inefficiencies – missed phone calls, unread emails and sharing of information, familiarity of site.
- Delay in receiving sub-contractor reports resulting in delay of client reports.

Stakeholders & Benefits

The stakeholders included Jones Engineering Services clients, account managers, administration staff, subcontractors, and technicians. For the Lean initiative to be successful, all parties needed to buy into the initiative for the collective benefit of the stakeholders:

- Jones Engineering Services sought to improve its processes in relation to reducing: (i) Return calls to sites to carry out additional works resulting in increased costs; (ii) Downtime for technician's fault-finding due to lack of familiarity of sites and assets; (iii) Administration time spent on tasks due to repeat or inaccurate calls; (iv) Management of subcontractor reports and invoicing; and (v) Time spent inefficiently maintaining defective assets through life cycle costing analysis.
- Clients would benefit from the process as they had easy access to the CMMS and their assets history with all the information available at their disposal to: (i) Reduce maintenance costs through operating efficiencies; (ii) Forecast annual budget costings; and (iii) Early failure warnings maximising their plant efficiency.
- Account managers gained a greater overall view of the status of contracts which resulted in less time dealing with non-productive issues and reduced administration workload, with increased efficiencies allowing staff to hit realistic targets and enabling enhanced job satisfaction.
- Sub-contractors had the incentive of timely and transparent payment on receipt/upload of accurate reports.
- Technicians gained increased support and knowledge increasing outputs, job satisfaction, and a corresponding bonus scheme was introduced.

Deliverables

Process deliverables included time logs spent to monitor tasks from call logging to closing a call, new standard operating procedures (SOPs) for subcontractors, KPIs and collection of data collated by the CMMS.

Measures of Success

The Lean initiative was measured using CMMS data collected previously and comparing the real-time data along with projection to monitor improvement progress.

The data for the measure phase in terms of the calls and KPIs was readily available for assessment as the system logs all the information for extraction; however, a time log from an administration view was assessed over a 1-week period to measure time spent vs productivity

Jones Engineering

Time Log

Task	Monday	Tuesday	Wednesday	Thursday	Friday
Assigning Technicians	3	5	5	4	3
Chasing Reports	5	3	6	5	4
Number of calls	34	29	24	31	24
Breached Calls	4	2	4	3	6

Figure 2.
Sample Time Logs

Once the measurement data was defined, a number of graphs were produced as part of the analysis phase. Graphs identified a re-occurring trend daily with the same average number of calls dealt with by the helpdesk; an average of 4 hours per day assigning the technicians to calls and ensuring that there were available resources to assign to the calls; and over 5 hours per day following up reports. This meant that a number of calls that required attendance were missing SLAs as a result of assigning technicians.

It was found that the root cause of the calls missing SLAs was the inability to get in contact with the correct technician whilst the flow of information wasn't getting through the system quickly enough, and sending unfamiliar technicians to sites where specific skillsets were required, and underutilising the technology available.

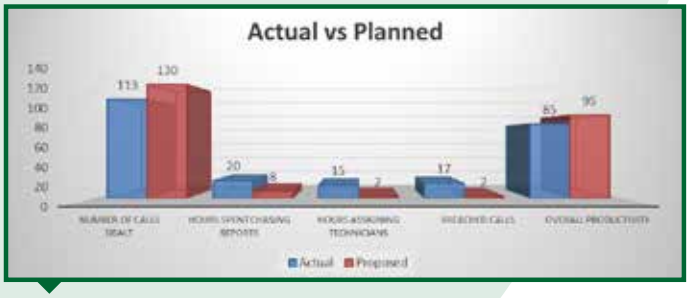

Figure 3.
Actual Weekly Average vs Planned

Lean Initiative Improvements & Impact

A team meeting was held amongst all stakeholders to suggest and implement improved strategies for the 8 wastes of Lean Maintenance as follows:

Defects impacting asset health

Life cycle costing analysis now allows clients to assess their overall costs with a repair or replace scenario using the history of their assets on the system. This eliminates time spent comparing and collating information from suppliers to compare the overall cost of disposal and purchase of new plant. The clients benefit from the application by ensuring their plant remains compliant whilst also assisting their financial planning. This tool implements a Lean maintenance focus to the client for proactive and predictive maintenance, as opposed to reactive maintenance, to ensure that their facility remains operationally efficient (Figure 4).

Figure 4.
Asset Life Cycle Costing Analysis

Overtime

The previous call history is made available to the technician's phone through the CMMS for the site in order to verify previous asset history and monitor performance, thus eliminating time wasted re-diagnosing issues with assets. This eases the flow of information from technician to technician and allows access to see who last visited the site, thus removing time spent seeking previous site attendees.

Work execution delays

A quotation request function has been added to the CMMS system to enable the attending technician to send the necessary details of the task for swift costing to office staff. This also allows the technician full access on their mobile device to see if the call had been quoted for previously. This allows for approval while the technician remains on site eliminating the requirement for the technician to return, thus saving in time and additional costs to the client.

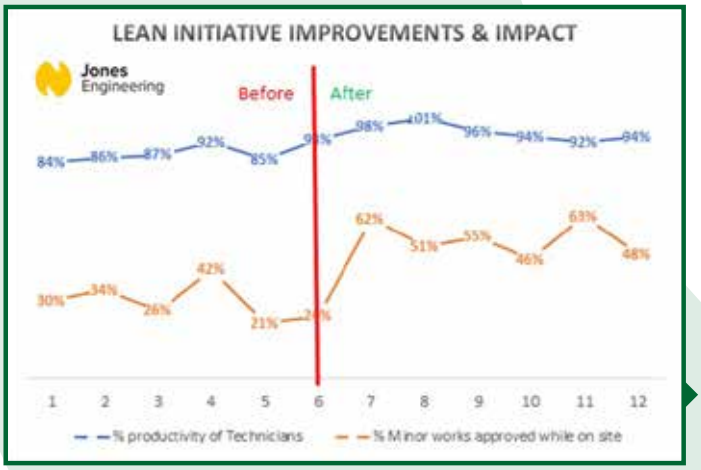

Figure 5.
Jones Engineering Productivity & Efficiency Lean Improvement

Non-Value-Adding Preventative Maintenance Tasks

When logging a call out, an asset and site history function has been enabled on our CMMS to automatically display similar calls and to identify if reoccurring calls continue appearing, or to assist in diagnosing or resolving calls over the phone.

Technology underutilisation

The introduction of a client mobile app to allow the client to log a call on their mobile device, incorporating a picture of the plant/description of the problem which is then logged on the CMMS system, eliminates time wasted from the passing of information from the client to the helpdesk and on to the technician. The mobile app also allows client access to the reports in real-time for download and electronic sharing.

Inventory overages and slow-movers

A traffic light system was implemented on the call as an overall visual aid for the prioritisation of calls. The traffic light system would prove to be an early warning system that the call is about to breach an SLA. It highlights that the process has been affected in order to implement remedies for the process to be put back on track, thus increasing quality control.

Motion excess

A function was added to the CMMS so that when a client site is selected the system shows technicians' locations on the basis of proximity and familiarity to the site. This allows for automatic selection of the technician by the system, thus reducing mobility times, reducing travel time and costs, and eliminating administration costs involved in phone calls trying to find a technician to attend.

Errors in Process, People and Procedures

A subcontractor portal has been incorporated into the CMMS wherein a subcontractor can log in to upload their reports to the appropriate call. This in turn triggers payment pre-approval for their invoices. It eliminates unnecessary time wasted on administration following up reports to add to the system and provides quicker visibility for our clients and account managers.

Jones Engineering

Company Overview | Kiernan Structural Steel Limited | kssl.ie

Kiernan Structural Steel Limited (KSSL) is a family business that was established in 1989 by husband and wife team, Frank and Dolores Kiernan. Starting from very humble beginnings by manufacturing agricultural sheds, KSSL has become one of Ireland's leading structural steel firms from its modern Longford-based plant. KSSL provides a wide range of services to the steel construction industry, including projects where clients request value engineering for their structural steelwork.

Our services include:

- Design Engineering
- Steel Fabrication
- Steel Erection
- Cladding & Roof Metal Decking
- Floor Metal Decking & Welded Shear Studding
- Castellated Beams & Steel Trusses Manufacture
- Fire Protection Painting

Authors

Peter Byrne

Andy Brophy

Overview & Background to the Lean Initiative

This project was undertaken to improve the transfer of information across projects and departments, and to move away from a reliance on paper. The approach taken to the project was to use the A3 problem solving methodology and a cross-functional team for Kaizen events for the roll-out of process changes. A broad array of Lean tools was deployed. Issues were identified and countermeasures were implemented to eliminate waste and improve the utilisation of the safety, environmental, and tendering team's time.

The net potential saving of €13,735 through time savings from the introduction of the electronic forms has also led to other savings not captured within this study, like, for example, increased customer satisfaction and better quality control.

Whilst the primary goal of this project was the elimination of time waste and efficiency improvement through introduction of electronic forms, it also demonstrated the potential benefits that can be realised by applying Lean principles across the organisation – including in support departments. There remain some limitations to the use of the system, and some departments still have not been fully brought into the system, but it is undoubtedly a move in the right direction for the organisation and has realised significant gains.

Lean Initiative Undertaken – Lean Thinking, Tools, Techniques

The main focus of this project is the development of an electronic forms system to replace the company reliance on paper and the development of a means of speeding up information transfer and capture for use by the EHS Team as well as the Quality and Tendering Departments.

In his role as Health, Safety, Environmental, Quality (HSEQ) Manager, Peter, as the primary driver of this project, began the process by researching the various options available for the creation and management of electronic forms. This research involved engagement with industry peers to understand what other contractors in the same working environment as KSSL were using to see if we could learn from their experiences to speed up our process.

From initial discussions, it was discovered that many contractors were using the same programme, and thus we downloaded and trialled it too. However, after some testing of that programme, it was found that although the app had many good features, it also had some fundamental flaws from a quality perspective. For example, a user could create a template for use – say, a weekly safety checklist – but in order to share this template with their fellow teammates, this document

had to be uploaded to a public library which meant anyone with the same app could access the template for their own use. That template, once downloaded by a teammate, could then be further altered which rendered document control meaningless, and therefore that programme was ruled out as a potential solution.

Other apps were trialled with similar results and/or limitations, until we discovered the GoFormz app. Following an initial trial of this app, we felt that many of the features needed were available in it, and so we proceeded to seek out examples of documents to demonstrate the potential time and effort savings.

We created several templates for simple and commonly-occurring checklists that were in regular use across all projects such as a 'Weekly Lifting Equipment Checklist' form and a 'Plant Safety Inspection' checklist, and uploaded these to the app. A meeting was arranged with members of the safety department where the app was debuted and its output analysed.

Several members of the team agreed to pilot the system on their projects, and subsequent amendments were made to the templates to improve functionality and speed up completion. The templates were designed so that typing would be minimal due to the small nature of the devices being used (phones and tablets), and so as much as possible the checklists contained tick-box fields and drop-down menus. The app allowed for the introduction of automatically-populating data fields, direct inputting of images and sketches, and signature fields. When the templates were finalised, the trial began properly.

Throughout this improvement initiative, we followed the Kotter Change Model, particularly the steps such as 'create a vision for change' and 'create quick wins', and incorporated Ulrich's recommended steps of beginning any change with asking Who, Why, What, How.

As a starting point, we focused on Daily MEWP Inspection to determine the current state of reporting within the organisation. A standard template had been developed for capturing this information on projects, but it was in a WORD format that was freely adapted across each project. These forms were issued to the operators of the MEWPs (Mobile Elevated Work Platforms), who then had to fill in the forms by hand daily. These forms would then be collected by the Safety Team, and a report compiled. A process flow chart for the completion of a Daily MEWP Inspection was created using information recorded during site visits (Figure 1).

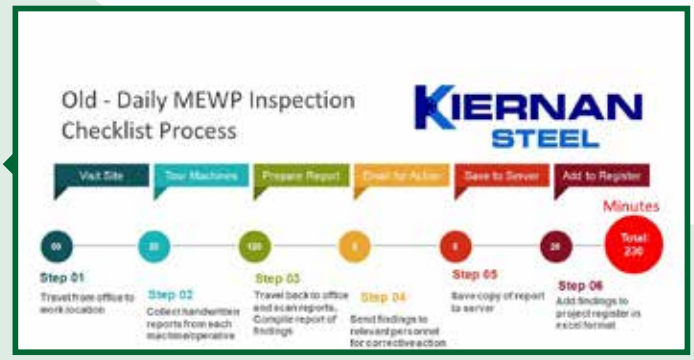

Figure 1.
Daily MEWP Inspections – Old Process

After completing the scoping exercise as outlined, we prepared and uploaded to GoFormz for completion of 'Daily MEWP Inspection'. A QR Code was also generated that linked to this form and for all users to access via their phones. Once the template was uploaded, we ran a training course with members of the Safety Team to demonstrate how the form was to be used on site.

Following on from this meeting, the template was amended following discussion to include additional information and automated workflows were set up to email the completed reports directly from the phone or tablet to selected personnel, as well as automatically generating an Excel report for administration staff. The discussions during this training also covered items such as the types of fields to be contained in the forms for rapid preparation of reports, such as drop-down menus, autofill dates, and checkboxes.

The further development of the system with the team moved towards the utilisation of the data source functionality within the system, which led to greatly reduced opportunities for error as one field could be used to populate the information in a consistent manner in many other fields and thus removing the potential for misspelling serial numbers as well as speeding up the entire process. A list of the specific details of each of the MEWPs on a pilot site were collected, as well as details of the different operators and their Safety Harness details.

Plant No.	Make/Model	Serial No.	GA1 Expiry
9	JLG 600 AJ	300161044	23/07/2020
10	Genie S65	S6016M-194	25/07/2020
14	Genie S65	S6012-24057	16/11/2020
16	Genie Z80	Z8008-2296	19/08/2020
18	JLG 800AJ-HS63	300272965	23/08/2020
21	JLG 800AJ-HS34	300258184	04/09/2020
22	JLG 800AJ-HS43	300258474	18/11/2020

Figure 2.
MEWP Data used for Report

Weekly meetings were scheduled to discuss the adoption of the forms across projects and the potential for new documents to develop. These meetings then moved to a monthly Skype call as the system became embedded.

Figure 3.
Operative Using Phone to Scan QR Code

Lean Initiative Improvements & Impact

The results obtained during this programme of work have far exceeded the initial estimations considered, as the initial aim of the process was to focus on the safety and environmental teams but the system was adopted by other departments at a rapid rate. This has led to a far more widespread usage than initially imagined.

At the time of writing, the GoFormz system has 150 annual licences purchased. From this data, we were able to calculate the following results over a two-year period from November 2019 to August 2020:

- GoFormz User Licences: 6 licences at €1,800 annually
- Hardware Purchases: As the system can be used on Tablets, Smart Phones, and PCs, three refurbished iPads were purchased for site usage at a total cost of €665.
- Time Savings: Following discussion with the Payroll and Tendering departments, an average figure for professional staff of €45 per hour was agreed for use in calculations. It was calculated that over a period of 30 weeks, an average saving of two hours, per user, per week could be made by utilising the app correctly, leading to a total of 360 hours or €16,200 saved.
- This figure of 360 hours saved, minus the investment required for hardware and licences, led to a total saving over the 30-week reporting period of €13,735 (note that the 30-week period excludes the Covid-19 shutdown period).

In essence, KSSL's introduction of GoFormz has been one of the largest continuous improvement processes undertaken, and has assisted the company in propelling itself forward to a more modern era.

The study undertaken of the time spent on completing the Daily MEWP Inspections reduced the time taken to complete a form by up to 228-minutes for each report.

Figure 4.
New Time Spent on Daily Reports

An unexpected additional benefit of using GoFormz was that during the Covid-19 shutdown period, we needed to ensure that our staff were kept informed of return-to-work protocols. WhatsApp groups were being used on each project to spread safety alerts and messages to all personnel, and this system was further optimised to send out the Covid Declaration forms to all of our workforce by texting them a link to the form. As the individual forms were completed, they were emailed to the C19 Officer, and a report was automatically generated from each form. This meant that a company-wide register could be collated prior to our sites recommencing.

Now that the system has been recognised as an effective tool for saving time and generating more professional and consistent information, its use is being expanded into other departments such as HR and Procurement. Our Quality Team also utilise the system to complete our RFT (Right First Time) forms which we use to track issues from design through to construction, and this enables a cost to be applied to any defect. The ultimate aim of this exercise is to measure our trends and generate meaningful data to focus our continual improvement efforts.

As noted in the McKinsey Global Institute Industry Digitisation Index 2015, and by many researchers, we need to imagine construction's digital future as the construction sector is amongst the least digitised. Thus, we went on to outline five big ideas for disrupting construction, and one of these five ideas is Digital Collaboration and Mobility which encompass the move towards paperless systems for real-time information transfer and analysis. KSSL feel that the introduction of this Lean initiative to the organisation has certainly helped move us in the right direction towards enhanced Digital Collaboration.

Figure 5.
Example of Completed Daily Form

KIERNAN STEEL

Company Overview | Sisk | johnsiskandson.com

John Sisk & Son Ltd. ("Sisk") is an innovative international engineering and construction company employing over 1,300 people across its operations in Ireland, the UK, and Europe. Sisk has the track record, scale, and capacity to successfully undertake large, complex, multi-disciplinary programmes, and we are recognised by our global customers as world leaders in safe delivery. Operating since 1859, Sisk is a progressive business with long-term vision and is ranked as Ireland's No.1 provider of construction services.

Sisk's strategy is to create value for customers, partners, and people through technical knowledge, ability, and experience:

- We collaborate with our customers and supply chain to provide technical and delivery solutions in an open and can-do way to meet aligned objectives.
- We offer a full range of solutions where safety, innovation, quality, efficiency, and value are integral to everything we do.
- We deliver projects and programmes in key sectors such as Data and Technology, Pharmaceutical and Life Sciences, Infrastructure, Transportation, Healthcare, Commercial, Residential, Retail, Industrial, Leisure, Education, Water, and Energy.

Author

Alan Flynn

Overview & Background to the Lean Initiative

The Project Team was tasked with constructing two blocks of student accommodation (145 bedrooms) on a particularly confined site in a residential area of Cork City. There were a number of key challenges, including:

- The building footprint covered the entire site to within 1m of the site boundaries, except for an open corridor between the two blocks.
- Working hours were limited by a 6pm finish from Monday to Friday, with no weekend work allowed.
- Project duration was only 15 months.

The structural frame was in-situ concrete. Typically this work requires a generous lay-down area and routinely ends up over schedule and over budget owing to the labour intensive and linear nature of the work, as well as susceptibility to weather and logistics issues. Poor productivity rapidly escalates when labour, deliveries, and cycle times are not all perfectly aligned.

The remainder of the project comprised the building envelope, external works, and the fitout of 145 student bedrooms and common areas. This element in particular would benefit from Lean techniques developed by Sisk on similar projects which involve significant repetition, getting the construction detail absolutely right, adjusting details and sequence such that each trade only visits each room once, and absolute insistence on defect-free handoffs from trade to trade.

Figure 1. Drone Footage of Top-Out Pour on Reinforced Concrete Frame

It was clear that delivering a "Lean Concrete Frame" was key to a successful project. The value of the concrete frame was 21% of the total project value, the duration was 7 months (of the overall 15), and by its nature the concrete works were entirely on the project critical path. We needed efficient delivery with high levels of productivity and with the target to deliver on time, within budget, and with zero compromise on quality or safety.

Lean Initiative Undertaken – Lean Thinking, Tools, Techniques

We focused on the following seven key Lean Concepts:

i. Training and creating awareness of Lean principles.

ii. Collaboration between all parties (designer, main contractor, and concrete frame contractor).

iii. Understanding the customer requirements.

iv. Map the value stream and focus on the detail to improve flow.

v. Maximise efficiency of plant, equipment, labour.

vi. Productivity of labour, measure and monitor output.

vii. Direct observation studies to aid productivity.

Training and awareness of Lean principles

The project team were supported from pre-commencement stage by Sisk in-house Lean specialists and through external training and mentoring delivered as part of our Lean Transform programme. All of the Sisk project team were trained as Lean Yellow Belts, with workshops between Sisk, designers, and contractors helping to secure support for the Lean execution approach.

Collaboration between all parties

We selected our concrete frame partner not only on the basis of cost, but on their previous experience. They had worked with us previously, understood our open project approach, and were committed to investing and contributing to a collaborative approach. The design team were also keen to engage.

Understanding the customer requirements

For the purposes of the concrete frame, we considered the design team and our concrete frame contractor as our customers. The structural designers needed a building that would be strong enough to fulfil its structural functions, as well as being structurally sound in all temporary conditions (mid-construction). The architectural designers needed structural detailing that would allow them to support the external facade for example. The mechanical-electrical designers needed to allow for openings in the structure for the passage of services. Our frame contractor needed a design that facilitated efficient construction, needed space onsite to lay down shutters and needed to limit any unnecessary use of materials, plant, or labour. Sisk itself was the customer of both the design team and the frame contractor, and we needed a design that maximised our efficiency and a rapid construction within a budget.

Map the value stream and focus on the detail to improve flow

The building had been designed to suit the final architectural and structural requirements, for example, four stair towers were designed to be constructed floor-by-floor in the same timeframe as the columns and slabs adjacent, and the elevated floor-slabs included a downstand beam on the perimeter of each floor.

The collaborative process concluded with a revised design, a standardised layout to suit the formwork systems of our frame contractor, and a revised stair tower design that facilitated early construction of the stairs to full height. This was a win-win solution – not only did the frame contractor now have space to lay down their bulky wall shutters, but they could also significantly shorten the overall hire period for these wall shutters and remove cranes from site at an earlier date. The designers also had more time to design the main floorplates by releasing the stair cores early.

Working together, we redesigned the internal leaf of the facade from blockwork to a lightweight steel frame system. This resulted in the removal of a concrete downstand to the perimeter of the reinforced concrete frame which provided a flat slab and soffit for the formwork system. We standardised the wall and column sizing to ensure that the formwork system was interchangeable between pours and did not have to be split and rebuilt following each concrete pour.

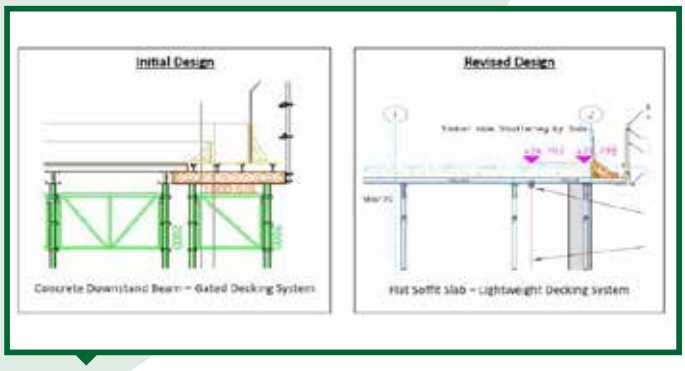

Figure 2. Downstand Decking System & Flat Slab Decking System

Maximise efficiency of plant, equipment, labour

The construction of an in-situ concrete frame can be broken down into a four-step process: install formwork; install reinforcing steel; pour concrete; and strike shutters. The plant and material resources are different for each step, and each step typically involves separate personnel. Planning the work to ensure continuity of efficient work fronts for everyone is difficult and depends on developing a cycle time and rhythm to the works.

To support continuity and to improve cycle times, our team changed the concrete mix design to secure faster curing times for finishing concrete – this allowed us to power-float slabs within the planning hours (18:00 off-site) whilst also ensuring earlier formwork striking times. Reinforcement design was enhanced – the normal commercial priority is to reduce the reinforcement content to the lowest possible tonnage and our Lean approach resulted in us increasing reinforcing steel content for two reasons, namely we standardised bar lengths for ease of fixing and we added steel to facilitate early shutter removal, thus enhancing cycle times.

Productivity of labour, measure and monitor output

We mapped out the targeted cycle times for each element of work and fine-tuned the resource requirements for each step. This allowed us to "flex" the resources to suit the workload. Output for each crew was visually marked and measured on colour-coded layout drawings daily, and this provided the team with certainty on cycle performance and also identified particular details where excessive labour was being absorbed. We reviewed these areas and fine-tuned details for the next cycle. Measuring the tonnage output of reinforcement allowed us to identify periods of activity where we could reduce and increase resources whilst also understanding which elements of the reinforcement were more onerous than others, like, for example, with shear links where we changed from a traditional shear link to a shear rail.

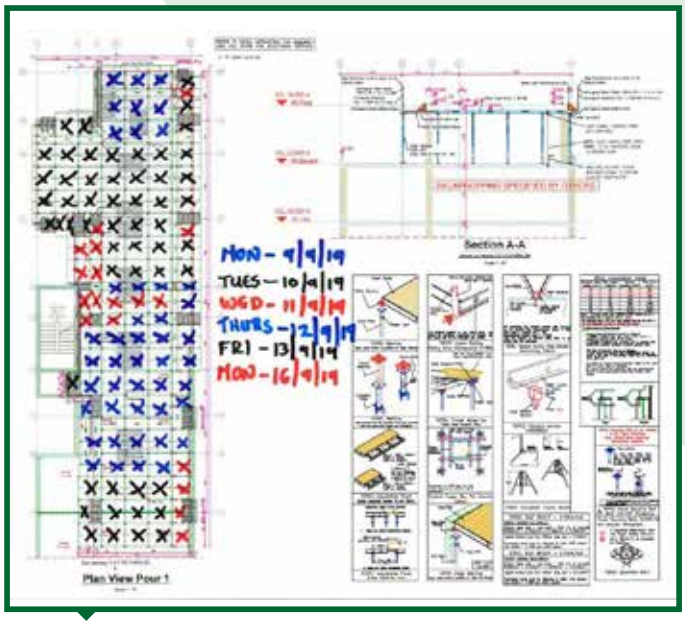

Figure 3. Example of Decking Installation Mark-ups for Progress Tracking

Direct observation studies to aid productivity

We engaged with specialist Lean consultants to undertake Direct Observation studies. We already understood the actual output rates per crew per day, and had identified particular construction details which were absorbing too much time. Direct Observation would provide us with independent data on where and to what extent waste was occurring within key activities, in particular, waiting, excessive transport, and movement.

Experienced construction professionals and supervisors understand the reality of moving materials on-site, the challenges of "crew sizing", and the inevitable intermittent downtime involved during concrete pours, for example. Sometimes we can "know too much" and thus in this project we engaged with a specialist Lean Consultant whose experience was in manufacturing and they would analyse our processes against a manufacturing type standard.

Prior to commencing the studies, we engaged with the craft operatives to explain the process and the purpose of the exercises, and everyone was happy to be involved. The following work activities were then observed and recorded on five days over a five week period, with feedback given to the site team after each visit and in advance of an overall report including:

- Erection of formwork decking.
- Installation of reinforcement.
- Pouring of concrete.

Erection of decking

This was characterised by significant movement and waiting, primarily associated with sourcing ancillary components, like, for example, fixings and ratchet straps. Crews were starting work with all bulk materials available in the correct location and with boxes or stillages of ancillaries to hand, but they subsequently lost a lot of time gathering the remaining components and bringing them to the location needed. The solution was to analyse the propping drawings in advance and organise the correct quantity of all ancillary items and deliver to the work area mechanically with the bulk materials.

Installation of reinforcement

Significant time was being lost sorting out the different bar sizes and shapes required for each area. The process involved checking the steel drawings to identify the bars needed, checking the steel schedule to identify the bar numbers involved, checking the bar tag to identify the correct bundle, and tape-checking the bar itself to confirm it was correct – all before taking the correct numbers of bars to the fixing location. The obvious solution was to re-design the steel so that there were fewer types of bars needed for each pour.

Pouring concrete

Extensive time is generally lost in part because of the timing of trucks – that is, a full crew waiting for the next concrete truck to arrive. Sometimes this is unavoidable or at least beyond the control of the site team – the nature of concrete is that it must be "just in time" and queues at the batching plant or traffic can delay trucks. However, the direct observation record showed that a five-person crew could (notionally at least) be reduced to four or possibly three. In particular, it was noted that the concrete pump operator was 60% waiting/not working.

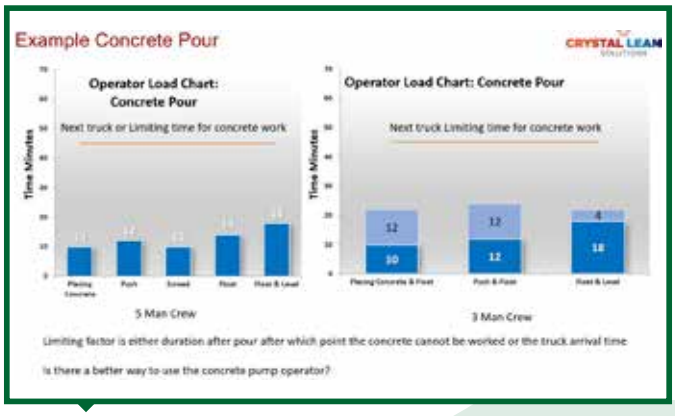

Figure 4. Example of Concrete Pour Breakdown

The summary report on the Direct Observation exercise identified that up to 48% of the time spent on certain elements of the works were "waste", primarily waiting, either for deliveries or waiting for materials from within site.

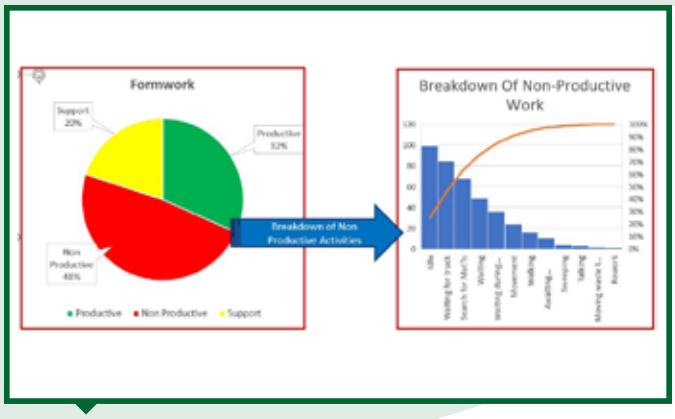

Figure 5. Direct Observation Summary Report Extract

Lean Initiative Improvements & Impact

The "Lean Project" approach had both a direct and measurable impact, but perhaps more significant is our enhanced awareness of the extent of waste on our projects. The nature and dynamics of a construction project are different to a manufacturing environment, but the cold theoretical assessment of wasted effort (up to 48%) certainly gave the team a number of opportunities for immediate improvement, as well as pointing to longer-term potential. Clearly the full 48% can never be eliminated, but we made improvements:

- The concrete frame was completed in 6 months, reflecting a one-month improvement on schedule.
- The concrete frame contractor and Sisk had a very satisfactory commercial outcome from the concrete frame package which represented 21% of the overall project value.
- The works were delivered to a high quality and with out any safety incidents.
- As the first significant package on the project, the success and the manner of execution of the concrete package set the tone for the remainder of the project.

There were a number of notable wins:

i. Revising the design and construction sequence to construct the stair cores prior to the construction of the main frame had a double benefit. It gave the design team additional time to design the under-slab drainage whilst at the same time allowing significant flexibility to construction. Four workfronts were open simultaneously with adequate laydown area available. Mobile cranes were required to construct the stair-cores, whereas the remainder of the structure could be constructed with more cost-efficient teleporters. Front-ending the stair-core construction allowed us to off-hire the mobile cranes early in the project, with resultant shared savings.

ii. Rationalising the frame design and eliminating the downstand beam allowed us to use a lightweight system which could be erected in a bottom-up sequence so that the decking system could be erected whilst standing on the slab. This not only had a safety benefit, but also cost and schedule benefits.

iii. Planning out the cycle times in detail in advance highlighted both problems and opportunities; for example, altering the concrete mix design to a higher strength concrete with a super plasticiser. For a standard concrete slab pour of 80m3, we started pouring at 8am, had the concrete installed by 12 noon, and were finished power floating by 5pm.

We then utilised the final hour of the day from 5pm to 6pm to pour column kickers which gained us a day in our reinforced concrete frame cycle. The higher strength concrete also ensured we were at our necessary 30N concrete strength after 3 days, enabling the stripping of the formwork decking system with associated back propping installed.

iv. Measuring outputs per gang proved to be a very simple task and gave us close control both of schedule and cost. The frame contractor field supervision could see immediately that the efforts were directed at boosting their productivity, not "catching them out", and they bought-in readily.

v. Direct observation studies provided simple approaches to pre-commencement activities to focus the tasks on maximising outputs for operatives once the task had commenced. The pre-task organisation brought immediate buy-in from the operatives on the ground as it removed their frustration in organisational aspects of their tasks and allowed them to focus on the productive elements.

vi. The formwork operatives on site were motivated, cooperative, and genuinely interested in the Lean techniques implemented on site. They were able to identify our interest in their performance and how we actively sought their feedback on the measures to find out what was working and how we could make alterations to further align the Lean initiatives.

BUILDERS SISK CONTRACTORS

Established 1859

Company Overview | Ardmac | ardmac.com

ARDMAC
Building Better

Ardmac is an international construction specialist delivering complex and high-value workspaces and technical environments. Headquartered in Dublin, and with offices in Manchester, Craigavon, and Brussels, Ardmac employs over 300 people and provides specialist services to the commercial fit-out, life sciences, and data centre sectors.

Ardmac's vision is to be "the contractor of choice for clients, and the workplace of choice for great people". Ardmac's mission is "to consistently provide the ultimate solution for high value working environments through continuous investment in the best people, technology, and processes".

Author

Fergus Nugent

Overview & Background to the Lean Initiative

Productivity improvements in the construction sector have been historically modest. It is a well-known fact that when compared to other sectors, construction does not perform well in terms of innovation, the use of technology, or improvements in productivity. In recent years, the use of Lean Construction (LC) principles and Building Information Modelling (BIM) have become more popular. There is significant research demonstrating that organisations that adopt these platforms, either independently or in tandem, observe significant benefits.

Hence, Ardmac started its journey to adopt Lean, BIM, and other digital technologies in order to streamline workflows and improve productivity. Ardmac leverages technology to support Lean Construction principles. There is such an abundance of technology today that it can be overwhelming. There are trends such as Pharma 4.0, Artificial Intelligence, Automation, and the Internet of Things that are already reshaping the construction sector and changing the way in which we all do business. At Ardmac, technology is implemented to improve processes that add value to customers, improve efficiencies, and solve specific problems. In order to do this, there is a big focus on gaining customer insights, understanding needs, and reframing those into desired outcomes. Once these desired outcomes are validated, solutions are delivered that address these unmet needs. We call this approach "Building SMART".

Lean Initiative Undertaken – Lean Thinking, Tools, Techniques

Productivity Tracking – Digitally

The company introduced Lean in 2015, and we have adopted several Lean initiatives across the company since then. We have been particularly successful with the adoption of Last Planner® System (LPS) which allows the proactive sequencing of works and setting of productivity targets. The targets are set using crew size and labour norms, and they are tracked daily and any deviations are monitored. Ardmac has been tracking field productivity for many years, and "Building by Numbers" is the terminology we use across the business as it is a simple and effective concept. Up until 2020, field productivity was monitored using a bespoke Excel tracker. Site Managers would track progress daily, and this data was inputted to a master tracker to highlight any trends and create a forecast at completion based on current production rates. This system, whilst reliant on paper-based information and double data entry, worked adequately for many years. Recently the process was digitised by working in conjunction with some software vendors, and now, using a function of the field management software (FMS) platform, progress, timesheets, and productivity can be monitored using any mobile device and site teams can now track the progress of crews in real-time in the field. The tool then provides instant feedback to the site team on their daily productivity, and this data is also visible to management and any downward trends can be rapidly analysed and steps taken to resolve any issues.

Safe Deployment of Labour

Managing labour on a project can be a significant challenge using traditional processes. Paper-based timesheets, inductions, logging credentials, and maintaining training registers can all take significant administration time, are prone to human error, and result in downtime which could have otherwise been used productively. Eliminating individuals arriving on site, either unannounced or without the necessary paperwork, is a significant time saving benefit for construction companies.

Using time and attendance technology, it is now possible for a new start to receive, in advance of their start date, a link to an online induction for both safety and quality that are site-specific. To complete the site induction, all essential credentials are first uploaded by the inductee, and the system also logs the expiry date of each credential. The process also includes reading and signing any specific Risk Assessment Method Statements (RAMS) relative to their role. The person is then issued a QR that allows them access to site.

There is, of course, a need for a site tour and familiarisation meeting with all new starts upon arrival, but the time is now greatly reduced as all paperwork is completed online. The time involved can now be better spent focusing on the crucial safety messages for the project rather than on scanning paper certs, logging details, and taking photographs. This process is equally effective for management, direct employees, and sub-contractors. The security entrance infrastructure can be scaled depending on the size of the project, and it can range from turnstile type barriers with biometric or facial scanners to mobile apps for smaller projects.

Implementing these systems alone delivers excellent results, but by linking multiple platforms together through custom built integrations, even further benefits can be achieved. Linking the deployment software to the FMS platform has multiple efficiencies as the site daily diary can be updated automatically, thus providing a record of site attendance on any given day. Site management can use the attendance register to assign the hours accrued by each person to the task they undertook on that day through the field productivity feature.

This real-time system provides management with crucial immediate records of who is on site, the workers safe deployment to the job site, and their productivity. Armed with this knowledge (on any mobile device) managers can devote more time to making decisions and being in the field supporting the project and less time at their laptops inputting data or reviewing spreadsheets that are immediately outdated.

Using LPS allows work to be planned effectively, removes constraints ahead of time and enables management to focus on productively delivering projects. By monitoring field productivity daily, variances can be tracked and LPS provides the facility to categorise these variances, and thus identify trends. Understanding field productivity in real-time and identifying trends from LPS is truly Building by Numbers and a SMART way of working.

Collaboration & Field Management Software

The use of largely paper-based information is one of several factors that contribute to the lack of efficiency in the construction sector. The traditional siloed approach restricts collaboration by creating barriers between parties to control information flow to mitigate risk for private parties. At Ardmac we wanted to source a platform to remove these silos and improve the flow of information on our projects.

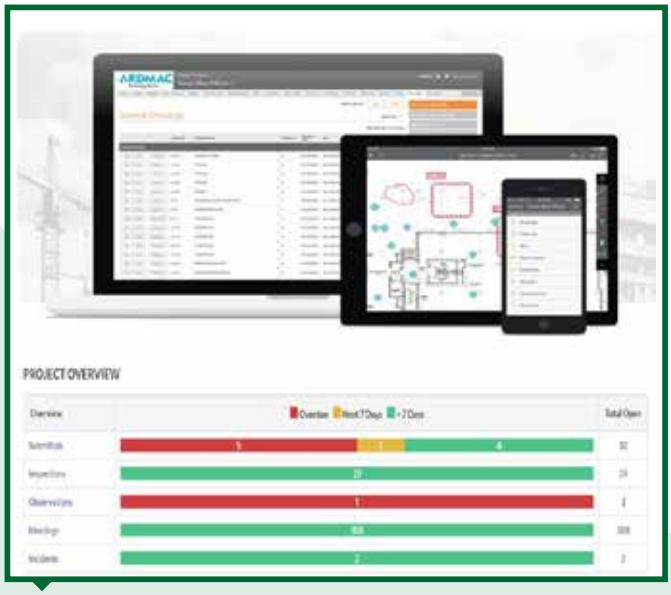

Figure 1. Project Health Dashboard

A new collaboration and FMS went live on all projects in February 2019. This provides a central cloud-based platform to share and manage project information, there is also a very strong inspection, quality, and safety management aspect to the software which enables the completion of inspections and audits using any mobile device. Project performance data is now captured in real time on all projects, which gives clients great insights into potential issues and thus focuses on proactive rather than reactive analysis.

Figure 2. Tools & Features

On-site is where most of the benefits of this technology implementation are realised. Efficiencies are greatly improved by removing the need for walking to and from the site office for information. Communication among all project teams has become streamlined. Each of the tools on the platform manage a specific part of the project, and all data is controlled via role-based permissions.

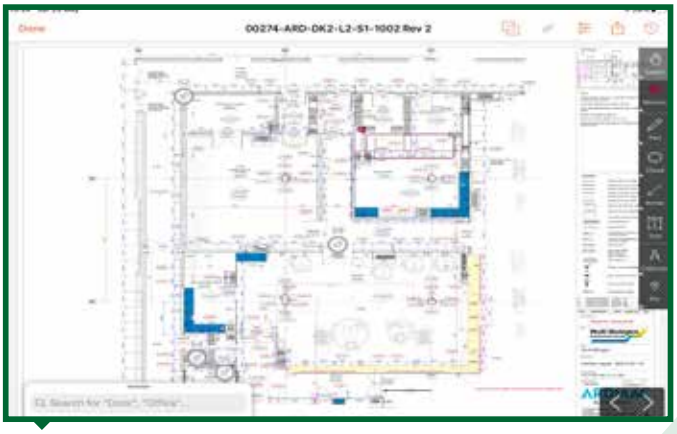

Figure 3. RFIs & Observations Linked to Drawings

Building Information Modelling (BIM)

Ardmac has been delivering projects through BIM for over 10 years. At first, this started with the creation of 3D models for coordination and clash-detection purposes. Over time and through experience and extensive training, BIM capability was increased on projects, including highly detailed and information-rich 3D models up to LOD500. Ardmac has since achieved ISO 19650-2 Certification with BRE, which demonstrates both commitment to BIM excellence and the capability to deliver projects using BIM.

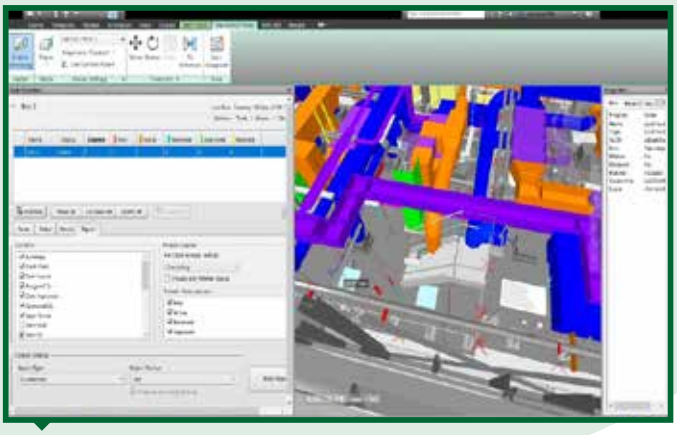

Figure 4. Navisworks Clash Detective

It is increasingly common for specialist contractors to be engaged at an early design stage of a project to form part of a multi-disciplinary design team. Cloud-based collaboration is enabling design teams to work together remotely from different locations. As buildings become more complex, it is crucial to have detailed expertise at an early stage to influence the facility design. This Lean approach reduces waste and possible rework further in the construction process.

Ardmac primarily use Autodesk products such as "Revit" for design, model generation, and layout drafting. "Navisworks Manage" is used for coordination with other trades and clash-detection (Figure 4). Project models are stored on BIM360 for cloud-based coordination of model files. We are working on several BIM initiatives across the organisation such as Design for Manufacture and Assembly (DFMA), 4D BIM, and BIM Viewers for tablets.

Figure 5. Mobile Model Viewer & Synchro used for 4D BIM

Lean Initiative Improvements & Impact

Building SMART

At Ardmac we define Building SMART as combining the three pillars of LPS: our Collaboration, our FMS Platform, and BIM. By implementing these tools and processes on all projects, there is a strong foundation for success. Clients are involved in the process and can see project performance in real-time. Information flows from one department to another both internally and across the company. Technology is only leveraged to solve specific problems which allows for the understanding of what works well and what does not. Ardmac is acutely aware that technology has the power to drastically change the face of the construction sector and we are committed to staying ahead of the curve. It is true that technology will support and improve existing processes at Ardmac rather than completely replace them.

Summary of Benefits

To summarise, we apply Lean Construction Principles and Technology to everything we do at Ardmac. By focusing on problems to be solved, we can apply technology in a specific and focused manner. The problems can come from a variety of sources such as customer insights, feedback from our site teams or market research, and we analyse these in

a structured innovation process that allows us to understand the next steps. We have a dedicated digital construction team to continue the trialling of technology with the goal of digitising all processes in the company, and we aim to deliver a paperless jobsite by 2022.

Figure 6. SMART Pillars

Our employees now link continuous improvement to Building Smart, and Lean Construction, BIM, and Field Software are at the heart of everything we do at Ardmac. We have found that linking all the three pillars enhances the results by bringing greater clarity. Groups and people across disciplines work in tandem rather than in conflict as we work towards common goals, and this allows people at all levels of the organisation to make decisions that help us become more efficient through linking their efforts to Building Smart. The use of digital tools has also been a massive benefit for us during the current pandemic and has allowed large portions of our support teams to continue to be productive whilst not being physically present on our sites.

This has a positive effect on our supply chain also. We collaborate with supply chain partners in the same manner using the same systems, and they also benefit from having access to clear and current information filtered to their specific scope of works. This greatly reduces frustration in sourcing information or the impact of additional costs due to rework. We believe that our supply chain is a crucial part of what we do and we are happy to support them in this manner.

Finally, we are very much client focused and maximise value for our customers. All these initiatives are implemented with the customer in mind. Customers can see real-time project information on any mobile device and the approvals processes can be managed easily including RFIs, Submittals, and Punches. These digital processes not only improve efficiencies for Ardmac but also for our clients. They enable us to be more competitive at tender stage while allowing us to deliver projects faster without compromising safety or quality. Building Smart allows us to consistently deliver excellence across multiple sectors and geographic regions.

ARDMAC
Building Better

Company Overview | Ardmac | ardmac.com

ARDMAC
Building Better

Ardmac is an international construction specialist delivering complex and high-value workspaces and technical environments. Headquartered in Dublin, and with offices in Manchester, Craigavon, and Brussels, Ardmac employs over 300 people and provides specialist services to the commercial fit-out, life sciences, and data centre sectors.

Ardmac's vision is to be "the contractor of choice for clients, and the workplace of choice for great people". Ardmac's mission is "to consistently provide the ultimate solution for high value working environments through continuous investment in the best people, technology, and processes".

Author

Aaron Clifford

Overview & Background to the Lean Initiative

Ardmac began its Lean journey in 2015 through client demand and implemented the Last Planner® System (LPS) in response to this client demand. After the successes of the LPS as its first Lean initiative, Ardmac has strived to bring Lean to the forefront of all activities across the entire business. In February 2019, Ardmac started to integrate its Field Management System (FMS) for use across all projects. That was another progression along Ardmac's Lean journey as it allowed the management of all phases and aspects of projects, from pre-development and bidding to project completion.

The latest progression in Ardmac's Lean journey is using Quick Response (QR) codes to store all information on each individual room in one single location on its FMS. This initiative started on one of our current projects for our Client, WuXi Biologics in Dundalk. Encompassing 13,000 sq.m., this project comprises the construction of multiple cleanroom systems, including walk-on-ceilings, modular partitions, lights, terminal filter housings, floor finishes, doors with door automation, and installation of downflow booths.

Lean Initiative Undertaken – Lean Thinking, Tools, Techniques

This case describes the project information storage practices and procedures prior to and following Lean implementation, an overview of Ardmac's FMS, and the approach to implementing the use of QR codes as a pilot initiative on the WuXi Biologics project.

Traditional Project Information Procedure and Storage Method

Before Ardmac's adoption of its FMS, we relied upon completing handwritten inspections, quality walks, safety walks on the site, and then going back to the office to scan, email, and upload all the information to the relevant parties. It was difficult to keep record of all information and it was a very time-consuming activity which led Ardmac to take the decision to implement its FMS as part of this Lean initiative.

Overview of the Field Management System

There are currently several FMS available in the construction sector. Ardmac's FMS allows us to manage all phases and aspects of projects, from pre-development and bidding to project completion. The FMS streamlines construction management in many ways, from easy document searches to automated delivery of documents and revisions to team members. The software maintains daily logs, progress reports, drawings, requests for information (RFI), schedules, specifications, submittals, and timecards. It also supports integrations with quality and safety software, and provides field productivity management tools and construction financials. It also enables team members to use these features on any of their devices, wherever they are located and in real time.

How Locations Work in the FMS

In our FMS, when one creates an observation, issues a submittal, or undergoes a quality inspection, that process can be assigned to a location to make that information more relevant. When a room is inspected, you want to have that location information included in that process so that other users can see where inspections have been completed and the photos you take can be associated with that location for future reference. A user can search a location which will display all the inspections, observations, RFIs, and so on, that have been linked to that location/room. From this, a detailed report of any location can be generated which will show all of the historical data and provide a timeline of events for that room.

The Obstacles with the FMS Locations Pre-QR Codes

The locations feature in the FMS is very beneficial; however, it does have a significant obstacle, namely the users. For example, person A might go into room 1001 on level 1 in building D, and complete an inspection and name the location "Building D > Level 1 > Room 1001" which is perfectly fine. The problem then is that person B might go into that same room and complete a separate observation and name the location "Building D > L1 > R1001". The problem with this is that, even though it is the same room and both ways of naming that room are perfectly fine in and of themselves, the FMS does not recognise that location/room as being the same location. The issue with this is that when other users search this location, they may only get the information that person B created depending on how the user searches for the information. If they search R1001, this will automatically rule out finding person A's information on this location simply because it does not match with Room 1001. This makes information hard to find it is very time consuming to gather a report trying to match up two different locations even though both users completed their respective inspections/observations correctly. Another obstacle that can be found on larger projectsmainly, is that there are so many rooms you do not know what room you are in and therefore have to search through drawings and look at gridlines to determine where you are before even creating the inspection/observation.

Linking QR Codes to the FMS

The way to overcome the obstacles with locations is to generate QR codes. Ardmac's FMS has a feature that allows a QR code to be generated in its software for each location. The QR code can then be printed and placed into that location. Now when Person A goes into Building D > L1 > R 1001 the first thing they do is scan that QR code that is placed in the room with their tablet or phone. When the person scans the QR code, all of the information that is associated with that location is now visible to them on the device, like, for example, punches, observations, and inspections, and you also know exactly what room you are in without having to look through drawings. Now they can see if an inspection has been completed in that room and they don't double-up on the work and do the same inspection that has already been completed. They may want to then create an observation and it will automatically link it to that room. Now when person B goes into that room, they follow the same process and scan the QR code and they can see that an inspection and observation has been completed in that room.

Before QR Codes Were Implemented

Figure 1 illustrates how the same room can have two different names and therefore represent a doubling-up of the same inspection. However, if the QR code is scanned then the person doing the inspection would have seen what inspections had already been completed or were open for them to continue with. The only difference in the name used is that the second locaion has DK2 in front of it. Even though both are the same location out on the site, the FMS recognises this as being two different locations.

Figure 1. Example of Inspection Report Duplication

Using QR Codes in the Field

The process is to simply generate the QR Code for each location within the FMS admin page, print off the sticker and place it in the room with which it is associated.

Figure 2. QR Codes Placed in Each Room

When you enter that room on site, you scan the QR Code within the FMS app which will take you directly to the information on that room.

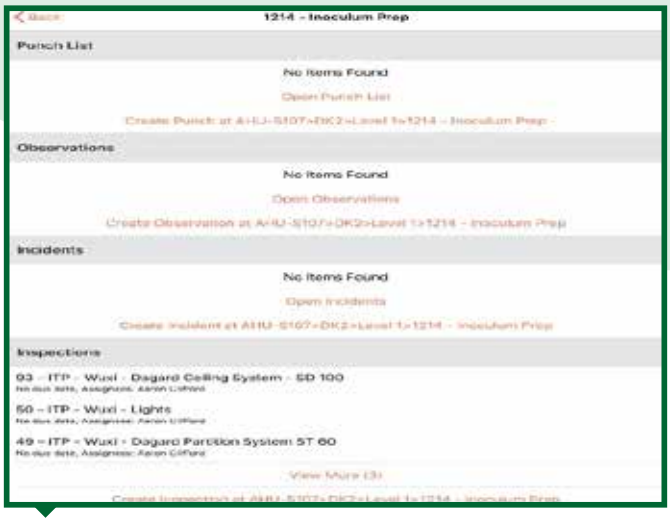

Figure 3. Post-QR Code Scan – all room information is in a single location

Lean Initiative Improvements & Impact

The key benefits arising from using QR codes in the FMS on this project include:

- Information on a room is now stored in a single location on the FMS servers rather than doubling-up the information by calling the same room two different names.
- Users can simply scan the QR code and see what room they are in and what has been completed in that room, thus making the inspection process much more efficient.
- Time spent searching through documents to see if you or someone else has already completed a task in that room is now eliminated simply by scanning the code and you can see instantly what you are looking for.
- Generating an end report on each location is simplified and you can be sure that all the information on that location is in the report without spending hours looking through each document to make sure you have what you need.
- Documentation for turnover packs are easily accessible – now it is simple to select the rooms you are handing over and the FMS will generate the documentation for the rooms selected.
- The documentation as a whole is cohesive, accurate, and relevant to each individual location across the project.
- Performance data is now captured in real time on all projects, which gives clients great insights into potential issues and thus the ability to focus on proactive rather than reactive analysis.

The ease at which handover information can be generated is a key benefit of managing project data digitally. All information in models and field management software is tagged based on location, system, and package. Thus allowing the extraction of information such as submittals, inspections, punch lists, drawings, and schedules based on handover sequence and the creation of handover packs. This is especially useful on complex technical projects where handover is typically based on a building utility system-by-system approach.

On site is where most of the benefits of this technology implementation are realised. Efficiencies are greatly improved by removing the need for walking to and from the site office for information by adding the ability to complete safety and quality inspections on mobile devices and by tracking the key project metrics such as open RFIs, overdue snags, and outstanding submittals. Communication among all project teams has become streamlined. Each of the tools on the platform manage a specific part of the project.

All data is controlled via role-based permissions, and this ensures data privacy is guaranteed for all collaboration partners. All project drawings are uploaded on the platform, and there is then an ability to overlay RFIs, inspections, photos, and other items and pin to the relevant locations on the drawings.

Further Improvements to Come in the FMS

Ardmac is now working on assigning labour costs to locations using the QR codes. This will work by management scanning the QR code for a location and then assigning the labour hours and task for the operatives working in that location on that day. This will provide us with a labour report throughout the project, which will show where improvements can be made, where particular locations giving us problems, and the productivity levels of each crew.

ARDMAC
Building Better

Company Overview | DPS ATG | dpsgroupglobal.com

DPS Group is a global engineering, consulting, and project management company serving high-tech industries around the world. DPS delivers services for clients across the complete engineering and construction value chain, including feasibility studies, concepts, consulting, architecture, engineering, procurement, construction management, commissioning, qualification and validation, as well as contingent staffing solutions. DPS applies its extensive process engineering expertise built over 45 years, as well as significant Lean construction experience to assist clients in high-end process sectors such as pharmaceuticals, biotech, and semiconductors to deliver manufacturing facilities speedily, safely, and cost-effectively. What sets the firm apart are the partnerships it builds with clients through a fundamental understanding of their businesses and its own agility, flexibility, original thinking, and high-calibre people. DPS has grown substantially in recent years and now employs more than 1,850 people in 14 offices and on client sites in Ireland, UK, Netherlands, Belgium, Sweden, Switzerland, Israel, Singapore, Saudi Arabia, and the United States.

Author

William Schofield

Overview & Background to the Lean Initiative

This case study demonstrates the application of the DMAIC (Define, Measure, Analyse, Improve, Control) methodology of problem solving to develop a global innovation roadmap for the DPS Advanced Technology Group (ATG). The DMAIC method for process improvement offers a structure for improvement initiatives that encourages both control and exploration in improvement endeavours, plus the active investigation encourages teams to be adaptable regarding diverse viewpoints.

Lean Initiative Undertaken – Lean Thinking, Tools, Techniques

The following is a summary of the five phases of the DMAIC methodology applied on this Lean project.

Define Phase

The define phase of the DMAIC approach utilised the following instruments: project selection, strategic planning, process mapping, and project management. Customer feedback on DPS performance was high regarding execution tactics. However, customers highlighted a desire to see a better strategic approach from DPS in generating and implementing strategic improvements. Acting on this voice of the customer feedback, we launched a multidisciplinary team to deliver the customer requirement for DPS to have a more effective process improvement strategy.

Measure Phase

The measuring stage of the DMAIC approach involved the use of data sampling and gap analysis. A large amount of project improvement ideas were documented across multiple DPS ATG international locations.

However, there was no central repository of improvement ideas and there was no mechanism for ideas to be shared between international sites. A multidisciplinary team was established with team members from each international DPS ATG site. Improvement ideas were collected from each site and added to a central shared repository.

To measure the effectiveness of each improvement idea, they were each scored on a scale of 1 to 5 for impact (I) based on money, time saved, and ease of implementation (E). The product of impact and ease of implementation produced a priority number (PN):

Priority Number (PN) = Impact (I) x Ease of Implementation (E)

In this measuring stage of the project, data was gathered on the improvement ideas' merits and gaps by applying the priority numbering system based on each idea's impact and ease of implementation. The dataset was then plotted for Impact versus Ease of Implementation to aid understanding of the collected data (Figure 1).

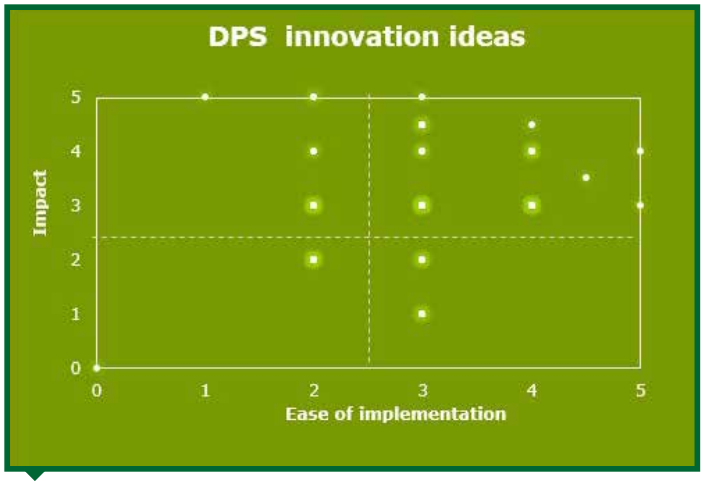

Figure 1.
Idea Priority Number

Analyse Phase

In the analyse phase of the DMAIC process, graphical improvement tools are frequently utilised. The gathered improvement ideas were classified into categorical data based on which quadrant of the Impact versus Ease of implementation graph they fell. Categorical variables represent types of data which may be divided into groups.

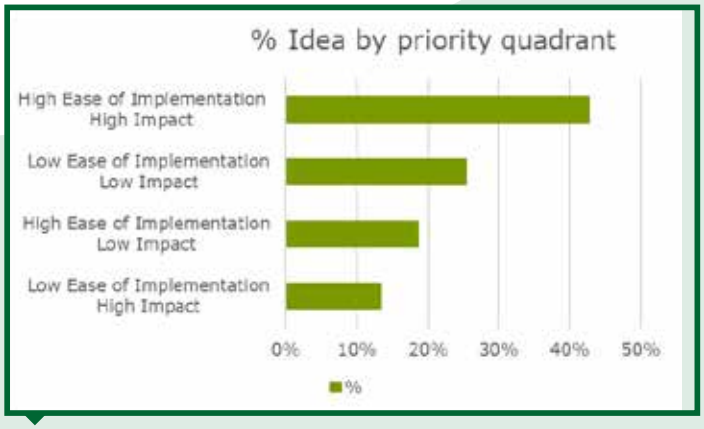

Figure 2.
Idea by Priority Quadrant

A graphical representation of the categorical data is shown as a bar graph (Figure 2), representing the percentage of improvement ideas by quadrant category.

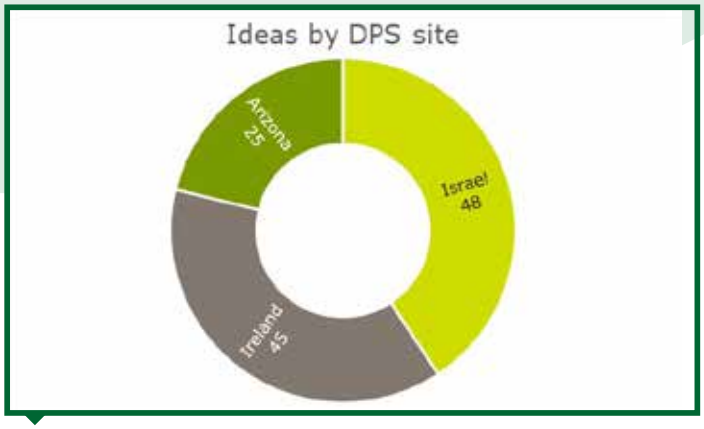

Figure 3.
Ideas by DPS Site

Improve Phase

In the improvement phase, ideas and designs were tested for their improvement impact. Appropriate remedial actions were planned after the analysis phase. A weekly idea-sharing forum was established with representatives from all international sites. An improvement roadmap was generated based on the ranked Priority Number (PN) scored for each improvement idea, owners were assigned to each improvement idea, and implementation dates by site were tracked.

Each site developed its own walk-in ideas weekly forum where staff could bring in improvement ideas to be added to the central repository, and have them assessed and ranked by priority number. The outcome was a ranked roadmap of improvement innovations for implementation at each international site. During this improvement phase of the project pilot, implementations were conducted for some of the highest-ranked projects to verify their impact. Starting in March 2020, and after implementing the above solutions, the number of improvement ideas generated each week was monitored and plotted as a run chart.

Control Phase

The final stage of the DMAIC approach involves the use of control plans and charts. During the control phase, the multidisciplinary team planned to gather and monitor the number of new ideas being generated over time. Here, a run chart was used to monitor the number of new ideas generated each week, and upper and lower process limits were calculated and added to the new ideas run chart.

This type of chart is referred to as a process behaviour chart. Process behaviour charts assist in identifying changes in process behaviour and allow them to be differentiated from natural variation in the process. Using a process behaviour chart allowed the identification of when the number of new ideas being generated was unnaturally low or high. This allowed program changes to be monitored for their impact on the number of new ideas being generated each week.

The upper and lower process behaviours limits were calculated from using the following formula:

Lower Natural Process Limit = Average -3 (Moving Range Average)/1.128

Upper Natural Process Limit = Average +3 (Moving Range Average)/1.128

The moving range is the absolute value of the difference between consecutive points on the number of ideas run chart. The average moving range represents the amount of variation in the idea generation process.

Lean Initiative Improvements & Impact

A total of 114 innovation ideas were generated, and 43% of these were assessed as having high ease of implementation and high impact. The rough order of magnitude cost-saving calculation for these projects was estimated as being between $18M and $72M, applying +/-50% accuracy limits.

This study proved to be an unusual and innovative application of the well-established DMAIC approach, and it helped identify $36M of project cost savings that had a high degree of ease of implementation.

Thanks to the multidisciplinary team conducting this project, the DMAIC approach has been demonstrated to be a highly effective strategy for the development of a global innovation roadmap. The development of a global innovation roadmap using a DMAIC approach has enabled DPS ATG to become a learning organisation. In a learning organisation, employees generate, attain, and transmit knowledge through the company, and the process of generating an innovation roadmap has created mechanisms for employees to develop, acquire, and transfer innovative knowledge throughout DPS ATG and which will enable us to add greater value for our employees, partners, and clients.

DPS Better Engineered Solutions

Company Overview | Modubuild | modubuild.net

Formed in 2006, Modubuild specialises in the delivery of internal modular fit-out and high-tech modular off-site buildings. With significant year-on-year growth, the company has focused its business model towards high-tech manufacturing, Biopharma, Pharmaceutical, and data centres.

Headquartered in Kilkenny, the company operates on an international basis with offices in Manchester, Brussels, Amsterdam, and Helsinki. With Lean thinking central to the company's operations, Modubuild has constantly evolved and applied CI and VSM to its operations. Working a hybrid model of directly employed and seconded labour personnel, Modubuild employs close to 300 staff across all regions.

Author

James Blanchfield

Overview & Background to the Lean Initiative

This organisational improvement initiative, using Lean thinking and practices, was carried out as part of the author's action research dissertation on the Waterford Institute of Technology (WIT) Executive MBA programme, and supervised by WIT's Darrin Taylor (LCi Capability Development Lead).

The Lean initiative focused on the improvement of the Tendering Process within Modubuild. The CI culture within Modubuild sees new systems and processes developed by the company to facilitate and improve company functions. It was recognised by senior management and acknowledged by department members that the tendering process had not evolved with the companys growth and it therefore required examination and improvement.

An obvious concern for the company was the use of Quantity Surveyors (QS) within the tendering stage because the assignment of QS personnel to the tendering process removed them from value-adding in the areas where they offer optimal value, namely, project commercial management.

A time impact analysis (TIA) of the QS team identified that some QS personnel were spending up to 80% of their working week within the tendering function, thus reducing their optimal value-add to project commercial management. Process mapping and reviews identified various wasteful activities and needless reworks within the tender process. Furthermore, increased client-driven tender deliverables required increased user input. These factors led to extended tender preparations that resulted in frequent tethering on the edge of submission deadlines.

Review of the pertinent data saw the company completely remove the QS from the tendering function. This saw the company create a newly formed and dedicated tendering team. In the creation of the new team, it was vital that personnel understood their role and responsibilities. The department lead worked to ensure that workload was delegated to personnel with the requisite skillset to enable optimal value-add to the process. The new tendering team was resourced from several existing employees plus some new recruits.

Lean Initiative Undertaken – Lean Thinking, Tools, Techniques

The team implemented Lean thinking and practices throughout the initiative. Firstly, the author, as process owner, needed to make considerations that the tendering team would consist of some existing employees and some new starts. Therefore, the change improvement process required some personnel to alter their work methods and new members to understand the existing process, but to be aware that the process would ultimately change.

To ensure that both new and existing personnel were content and understood the improvement process, it was essential for an appropriate change model to be adopted. Research into change models yielded some successful outcomes; however the use of Kotter's change model was chosen over other models as it allowed greater flexibility throughout the process for alterations to the change action and it is aligned with Lean philosophy, and people, empowerment, collaboration, and small wins are integral to both.

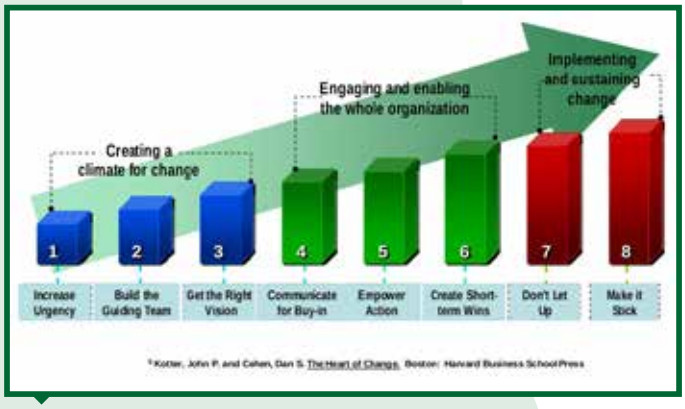

Figure 1. Kotter's Change Model

The success of the initiative hinged on the development of accurate data and not on inference, personal sentiment, or bias. Furthermore, it was essential that the data collection methods reflected the needs of the improvement process. The current state analysis allowed the team to create an illustration of the current state and formed a foundation for the entire intervention. Cognisant of the mapping session and its importance in shaping the direction and success of the intervention, it was important for everyone to discard any prejudgements or bias. Furthermore, it was important to remove any perception of Senior Management bias that might have been interpreted by team members.

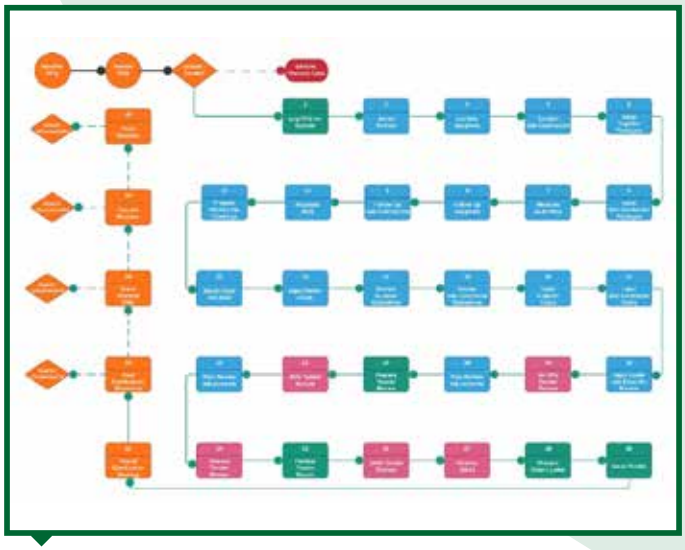

Figure 2. (Then) Current State Map

Consistent with the core Lean tenet of gemba, everyone was involved and had a voice in the mapping process. It was essential for culture and for a successful implementation that every team member felt part of the improvement and that they formed a fundamental part of the process mapping activities. In its totality, the then current state tendering process involved 33 high-level steps and approximately 150 sub-steps. From this, a workload analysis was developed to provide an understanding of which person took ownership of specific tasks. This identified that a disproportionate volume of workload – 53% – was being carried out by a commercial estimator (previously QS), whilst the workload allocated to others was substantially less. Furthermore, the commercial estimator had responsibility for completing 82% of the 150 sub-tasks.

Figure 3. Task Analyses

The next part of the intervention was to carry out a Waste & Why analysis of the tendering process using the 8-Waste categories of TIMWOODS. Using the process map, 25 wastes across multiple tasks and sub-tasks were identified, three of which were identified as NVA and which were completely removed from the process, and one step was identified as NNVA – a form of duplication – and this was subsequently removed.

Additionally, a skills analysis was performed which offered helpful insight into the extant skills within the team. This enabled the process owner to develop a detailed understanding of the team, and how to more efficiently allocate task ownership to personnel who offered greatest value-add to the process. Furthermore, the skills analysis provided important data around areas where the gaps lay within and offered areas for upskilling and empowering of personnel with new tools and knowledge.

The data obtained from the process mapping session highlighted the need for end-to-end improvements of the tendering process. The data collection and diagnostic stage of the intervention offered concerning metrics and evidence that the existing delegation model was outdated and inefficient. Maintaining compliance with Lean philosophy, the process owner ensured the team were central players in development of the overall solution.

In order to ensure the team understood the need for, and supported, the change, it was imperative for the process owner to convey the benefits of the intervention and how it would have a positive impact on each individual. Any resistance to change was temporary, and, by presenting the actual data to them, it encouraged personnel to support the improvement process. This was a critical stage in the context of the change model – particularly in the transition from steps 1 through 3 (creating a climate for change) and

on through steps 4 to 6 (engagement and enablement).

The climate for change was created through the acceptance of the issue, and user engagement was at the forefront through the data collection stage. This made steps 1 to 3 quite simple to complete; however, to ensure momentum through steps 4 to 6, it was key to maintain user input and collaboration.

In designing a suitable delegation model, the team chose to work with the RACI form of delegation. The RACI matrix offers delegation of task ownership and responsibility using four criteria: i) Responsible; ii) Accountable; iii) Consulted; and iv) Informed. This model allowed full traceability through the tender life cycle. Furthermore, if awarded the project, it allowed the construction management team to know the relevant person to contact with queries about the tender, which subsequently led to more efficient communication and information transfer.

Figure 4. RACI Matrix – Roles & Responsibilities

Delegation of workload to personnel with the requisite skills was the basis of the improvement. In doing so, it was crucial to understand the skills of the team and the positions of those involved. Understanding these parameters enabled the matrix to be soundly populated in an efficient manner.

The skills of each team member were apparent from the skills and knowledge analysis. This made it somewhat simpler to allocate tasks to those who added greatest value in terms of know-how and the skills required to execute the specific task.

Positive delegation shares some common traits with the Lean principles that formed a steadfast element of the intervention. This was particularly so around empowerment and using delegation to determine a classification for delegation and priorities within a process.

Furthermore, in the delegation of workload and drawing from the Katz Management Skills Matrix and Maslow's Hierarchy of Needs, the process owner ensured that the delegation phase took cognisance of position and the needs of each person. It was imperative for task accountability not to exceed a person's position, and, in balancing this, it was critical for morale that the needs of each person were considered.

Lean Initiative Improvements & Impact

The expected outcomes of the intervention were the design of a template to provide role clarity, reduction in the workload of the commercial estimator by delegating certain tasks to others; review of the existing process; and reallocation of workload to team members. In line with these objectives, the expected impact was achieved. The success of these objectives resulted in improved efficiency throughout the department.

The process map provided the data pertinent to the subsequent analysis. The post-intervention process map offered essential data that has enabled successful delegation. Moreover, the initial process map allowed for a detailed waste and why analysis, as well as skills and knowledge analysis.

Initial review of the process map identified 35 steps. The first round of NVA analysis resulted in the removal of four NVA steps, with one step being identified as a duplication. A second analysis carried out by all department personnel saw the removal of a further five steps. Additionally, some steps were re-positioned as sub-tasks. The outcome of this analysis provided a streamlined process map containing 20 steps. This represented a total reduction of 12 steps and a removal of 35 per cent of the prior process.

The implementation of the RACI matrix has proven to be very successful. While this intervention is underpinned by Lean principles, the efficient delegation of workload through the RACI template has further enabled personnel to better understand their position and role. Furthermore, it has removed role ambiguity and improved work and communication flow. Additionally, tenders are completed on schedule.

For Lean to be successful, it is important that employees feel valued, and, throughout the intervention, the voice of the internal customer (employees) has been at the forefront of key decisions. The completion of the RACI matrix was no different. During the delegation phase, the whole team discussed and were responsible for delegation of task ownership. The employees involved understood the need for efficient delegation and the purpose to remove certain tasks from the process.

In all, there are now 20 steps to the process containing 30 key tasks that are central to tender completion. These tasks are, for the most part, allocated and accountable to personnel within the department and there is a wider input from other department leads who are consulted and informed regarding certain decisions.

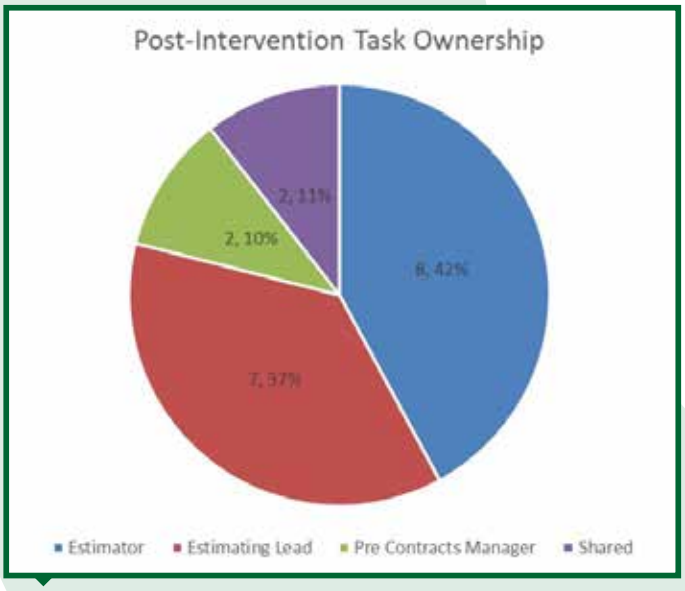

Figure 5. Post-Intervention Task Analysis

There have been various unexpected impacts during this action research project (ARP). The success in delivering the expected impacts brought much satisfaction to the process owner and team; however, it has been the unexpected impacts that have had the greatest effect on the company. These impacts have been apparent at the gemba, through the people who are directly involved and visible through the improved department performance. Additionally, from a financial perspective, the impacts have been considerable to the business.

An example of an unexpected impact was the identification of reduced project commercial management. This finding has enabled the recruitment of a dedicated tendering team. In further developments, it has been agreed by senior management that the new tendering department has been a success. The improved work and communication flow coupled with role clarity has ensured personnel are working efficiently and effectively. Flow is streamlined, with a specific owner who has responsibility or accountability of the allocated task. The dual function of the QS and time allocation towards tendering caused concern. Using the pertinent data, the QS was completely removed from tendering. This enabled the QS to focus on project commercial management, ensuring the projects are run on budget and protect profit margin.

It is no coincidence that removing the QS from the tendering function coincided with improved project financial prudency and resulted in improved project financial reporting and performance.

The practical impact of the improvement has been the introduction of workload delegation through the RACI matrix to inform personnel of their responsibilities. The implementation of a standardised format for delegation has resulted in improved efficiencies across the tendering process. The core objective from the outset was to reduce the NVA tasks that were being carried out by the commercial estimator and to delegate ownership of these tasks to personnel who added most value. Additionally, the intervention has enabled CI and for the complete removal of various wastes.

It is difficult to measure whether the intervention has enabled faster completion of tenders. It certainly has created a work environment with improved information flow, timeline awareness, reduced role confusion, less ambiguity, and simplified decision-making. Furthermore, workload allocation is now spread efficiently across the team, with tasks delegated to personnel who bring greatest value add. Critically the intervention has enabled the creation of a fit-for-purpose delegation model and allowed for a detailed process review. These alterations to the SOP, coupled with efficient delegation of tasks, has allowed personnel to apply greater attention to their work and subsequently allowed for improved due-diligence, consistency, and quality, with reduced errors and rework.

Prior to the intervention, revisions were not measured and were accepted as part of the job. Since carrying out the waste and why analysis, personnel have been acutely aware of the need to remove or at least reduce reworks. The large volume of rework was primarily a result of defective or insufficient information being received from the client and the quotation proceeding with a list of assumptions and qualifications. Subsequently, the client raised queries and requested clarifications which resulted in a tender being revised. Following detailed review of tender packages, personnel are now empowered to raise RFIs from clients. Prior to this improvement, personnel did not believe that they had the responsibility nor the authority to issue queries to clients – they believed this was a task only to be carried out by the PCM.

This intervention was completed in May 2020, and the Modubuild CI journey continues based on its impact and learnings which have enabled the wider organisational development of an enthusiastic team of proactive problem solvers seeking enhanced value both internally as well as for our partners and clients.

MODUBUILD

Company Overview | Mercury | mercuryeng.com

MERCURY
YOUR VISION. OUR DUTY.

Mercury is a European contractor that builds and manages complex engineering projects that reimagine how people work and live in the built environment. Mercury believes that real innovation happens if you are willing to be brave. Its determination and sharp focus enable Mercury to deliver leading-edge construction solutions across a range of key sectors, taking our clients to new territories they never thought possible.

Mercury's purpose is to deliver its clients vision through leading-edge construction solutions, going beyond their duty which turns clients into partners and builds relationships that thrive across the following Sectors: Enterprise Data Centres; Hyperscale Data Centres; Life Sciences & Technology; Building Services; Healthcare; Fire Protection; and TSS.

Author

Jason Toomey

Overview & Background to the Lean Initiative

Company Overview

Mercury began its Lean journey in 2014 with a great deal of energy and enthusiasm. Through our Yellow and Green belt programmes, many Lean projects have been undertaken and successfully implemented across all of Mercury's business units in Europe. Like most organisations that are on their Lean journey, Mercury hit a state of homeostasis after a couple of years of success and lost some of its original momentum.

In the last year, Mercury has refocused its efforts, and, by following the Plan, Do, Check, Act (PDCA) continuous improvement cycle has set up a governance structure to manage its Lean implementation plan and roadmap. The Mercury senior management have been actively involved in communicating our Lean philosophy across the organisation. We have re-established our Lean training program, with ten members of staff gaining Green Belt accreditation and one gaining Black Belt accreditation.

The Lean initiative discussed in this case study examines the modular wiring system design and installation on a large-scale project in Ireland. The objective of this project was to reduce the time taken to produce Modular Wiring 2D drawings and reduce waste on-site utilising Lean Principles. The DMAIC methodology was used for this initiative, with several Lean tools utilised, including: Gemba Walks; Brainstorming; Current State Mapping; and Cause and Effect Diagrams. Collaboration and communication also played a significant part in the success of this initiative.

Figure 1. DMAIC Methodology

Lean Initiative Undertaken – Lean Thinking, Tools, Techniques

Multiple cross-functional teams collaborating together is required to produce the end result of a modular wiring system designed, manufactured, and delivered to site. This includes the Site Engineering Team, BIM Modellers, CAD Technicians, Modular Wiring System Specialists, Lighting Control System Specialists, Project Design Consultants, and Electrical Distribution Board Manufacturers.

A kick-off meeting between all the modular wiring stakeholders, that is, the "internal customers", was arranged to complete the following:

- Communicate to the team the nature of the project, the reasons for selecting the project, and what the improvement expectations and goals for the project were.
- Select an initial cross-functional team and appoint a team leader for the improvement project, and communicate this to all stakeholders, as well as identifying all team members' roles and responsibilities for the project.
- Ensure buy-in and approval from the stakeholders for the project.
- Initiate and communicate a timetable for the meetings and activities required to complete the project.
- Generate a project charter to define the objectives of the project.

Using the DMAIC methodology, an action plan/timetable was generated detailing the durations for each phase of the project and with the appointment of cross-functional cells at each phase (Figure 2).

Figure 2. Improvement Initiative Action Plan & Timetable

Lean Initiative Life Cycle

At the first project meeting, the phases of the project were identified as follows:

- Define the problems in the process in more detail and develop a strategy to accomplish the goals set out in the charter. All agree on project goals and how the project would be considered a success.
- Investigate the root causes of the wastes identified through analysis of the current modular wiring process state, and map the modular wiring process as it stands today through completion of a current state value stream map.
- Select the tools and practices most appropriate for eliminating the wastes.
- Implement the tools and practices selected and measure any improvements.
- Evaluate the project results and review any key learnings. Document and standardise the new and improved modular wiring processes.

A gemba was scheduled of both the drawing production itself and the plan for how the on-site modular wiring was intended to be installed. Once the gemba was completed, the team scheduled a brainstorming session and a cause and effect exercise which identified several different wastes, including:

- Very little storage space was available on-site to store any of the modular wiring intended for site.
- Large bottlenecks were quickly identified within the drawing production process at various review stages and several process steps could be seen as being non-value-added.
- Given the vast size of the construction project, a plan would need to be implemented to avoid the install team having to travel long distances to retrieve the modular wiring for their install in each construction zone.

The team was then tasked with gathering the data of what is currently taking place in the modular wiring drawing production process, and identifying the wastes in more detail through Cause and Effect Diagrams. This information was then used to produce a current state map which clearly identified the wastes and delays in the drawing production process, as well as to quantify the actual time it was taking to complete each step. The first construction zone where the general services and lighting modular wiring drawings were produced was picked as the current state process which would be used to gather the data. Each stage of the current state process was documented with the person responsible for each step identified and the time taken to complete the step confirmed through a process step tracker.

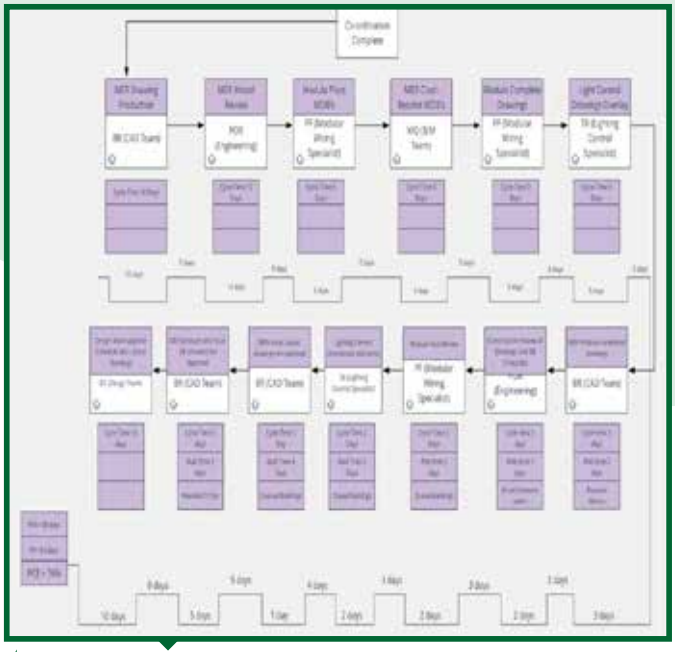

Figure 3. Current State Map

Through the above Lean tools and practices, a number of wastes were evident in the current state map, along with re-occurring errors, queues, backlogs, and unnecessary process steps (see Figure 4).

Location of Waste	Potential Action to Address
MER model review held post-model completion with 10-day cycle time.	Step could be incorporated prior to model completion, thus removing step completely from value stream.
Drawing produced at first step, but DB schedules produced through CAD at a later step added a further 10-day cycle time to the process.	During brainstorming with cross-functional team, it was identified that the DB schedules could be produced as an export from the BIM model, eliminating the need for the 10-day cycle process step and allowing the DB schedule to be produced at the same time as the initial drawings.
Several errors and reworks were causing delays, including, wait times, queues, and back logs in the value stream (10-day wait time). Only 1 review stage by engineering team identified close to the end of the process.	2 additional engineering review stages to be added to value stream – 1 prior to issuing drawings to Modula and 1 on receipt of modular drawings from specialist – to ensure any errors are captured incrementally and dealt with promptly as no back and forth between various stakeholders required.
The lighting control specialist was involved in 2 separate process steps which caused unwarranted queues.	Incorporate the lighting control overlay and the addition of the dali zones to the lighting drawings as one process step.
Lighting and General Services Drawings issued at the same time, but, through monitoring of the current state value stream map, it was identified that the general services drawings could be issued for approval earlier than the lighting drawings as less process steps were involved.	Work split between 2 CAD team members – 1 working on Lighting and 1 working on small power at the same time. On completion of general services layouts and post-modular wiring review, the general services drawings were issued for approval whilst the lighting drawings would continue through the final process steps.
Queues and backlogs evident at issuing of layout drawings for approval step (3-days) due to verbal communication that drawings were ready to issue.	Electronic notification system implemented with visibility from all team members to ensure accountability in issuing drawings in agreed time frame.
It was identified that, due to additional review stages being added to the value stream, the final review by the modular wiring specialist was not required.	Final review by modular wiring specialist removed from value stream and thus removing 5-day lead time at process step.

Figure 4.
Waste Analysis

A future state value stream map (Figure 5) was then created by the team to gain visibility on the improvements from the current state map generated, to further develop the improvements steps identified, and to review what the new lead time and value-added activities would be if the improvements were implemented. Construction area Level 3 Zone 2 was identified for the improvement project with a drawing production start date end of October.

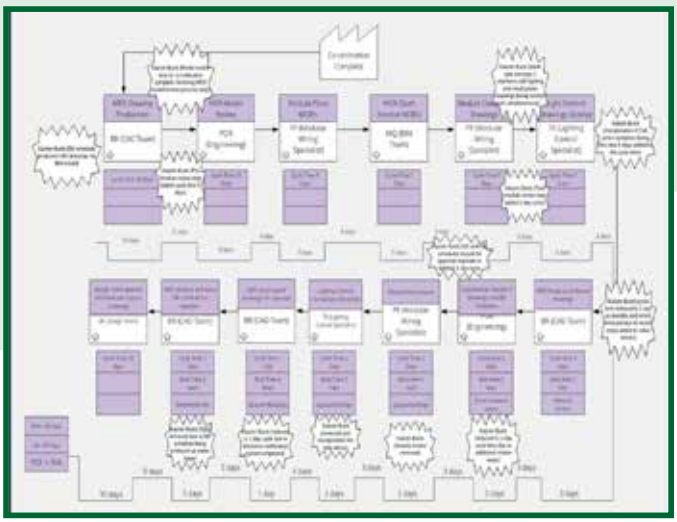

Figure 5.
Future State Value Stream Map

On completion of the future state value stream map, a new process step tracker was generated which detailed the new process steps involved, with the redundant process steps from the current state value stream map removed, and the new process step durations indicated from implementation of the improvements. Overall, this identified that the new proposed lead time of modular wiring drawing production was reduced from 85-days to 65-days.

A meeting was then scheduled with the BIM team, CAD team, modular wiring specialist, lighting control specialist, project general contractor, and the project planners to discuss lead times for manufacturing of the modular wiring for a given construction zone. This indicated 35-days and this was added as a process step to the new process tracker produced. Access dates for modular wiring install were identified for each construction zone by the general contractor, and these were also added as a process step to the process tracker to ensure commencement of manufacturing of the modular wiring for a given construction zone would only be initiated within a timeframe that would allow minimal storage prior to delivery and thus allowing JIT deliveries. Model completion dates were added to the process tracker by the BIM team for each construction zone to ensure the CAD team, modular wiring specialist, and lighting control specialist were ready to commence drawings once the model was complete. The process tracker was issued to all stakeholders to ensure dates were kept as agreed and all stakeholders had visibility of where the modular wiring process was currently at for a given construction zone, thus initiating Pull into the modular wiring process.

Finally, agreed by all parties and added to the PO was that, rather than the modular wiring being delivered to a central storage location, the modular wiring for a given construction zone would be delivered to the construction zone itself, thus ensuring the modular wiring was stored in close proximity to the installer and motion waste reduced.

The tools and practices used for each phase of the project are listed below:

- Phase 1 (Define) – Brainstorming was used during the initial meetings to build involvement, commitment, and enthusiasm for the project, and to both help to define the project more clearly and allow the team to think more critically in terms of solving the issues surrounding the modular wiring process. Direct Observation and Gemba Walks were used to better define the problem by studying the area and gathering the information which would be useful during the measure phase of the project.
- Phase 2 (Measure) – A Current State Map was generated to analyse what value-adding and what was non-value-adding within the modular wiring process, and it also helped us to make informed decisions around which improvements to focus on. Cause and Effect Diagrams were used to investigate what were the non-value-added activities in the process and what wastes could be identified.

• Phase 3 (Analyse) – After analysing the data gathered, a Future State Value Stream Map was generated to identify the improvements that could be made from the (then) current state value state map and to tackle any wastes within the value stream. JIT deliveries were identified as a tool that could be used to reduce the amount of transport wastes both onsite and in the office.
• Phase 4 (Improve) – A Value Stream Action Plan was used to clarify what steps and resources were required to reach the end goal, and what needed to be done and when.
• Phase 5 (Control) – Communicate results and document new modular wiring process. We then documented and standardised to ensure the improvements made are maintained and the new value stream is visible to all stakeholders allowing each person within the stream to know their responsibility, what they now need to do, when they need to do it, and when they need to have it completed by.

Lean Initiative Improvements & Impact

The project charter was a key factor to the successful completion of this project. With the charter, we were able to communicate the necessity and value of the project to the sponsor, stakeholders, and project team. In a sense, the team was able to sell the project to the people that mattered with this high-level document. When the project hit roadblocks and people asked "Why are we doing this?" we were able to refer to the charter to show people what we wanted to achieve on the project in the first place. The project charter was the "contract" for what, why, who, where, when, and how the project was delivered. With the project charter we were able to effectively manage the project's triple constraints of scope, time, and cost. When one changed, the other two had to be changed as well.

The investigative tools such as the cause and effect diagrams and the value stream mapping have been an invaluable tool to us in identifying wastes and non-value-added activities, not only within the modular wiring process but in all other systems for which we are responsible for in our scope of work on this particular project. Not only have the investigative tools been an excellent source of information to us, but the Lean focus on waste ("Muda") is something we intend to continue to try and identify in the future along with creating flow in our processes.

A value stream action plan was generated to ensure that all team members were aware of what was needed to be done and when. Improvements were measured via the action plan and through the future state process tracker. This worked well as all team members had clear visibility of their responsibilities over the life cycle of the project.

All durations as per the action plan were met apart from one step of the General Services drawings process. Unforeseen additional electrical services were added by the client as a variation and which added 10 days to the process to allow for incorporation of the additional circuits to the modular wiring general services drawings. This was unfortunate as the change was only initiated by the client when we were at final review stage of the general services drawings and ready to issue to the client design team for approval.

Lighting Modular Wiring drawing production was achieved as predicted in 65 working days, thus reducing lead time by 20 working days and achieving what the improvement project set out to do.

JIT deliveries have been implemented for the construction zone used in the Lean project. The application of JIT in construction differs greatly from the manufacturing industry because of the complexity and schedule uncertainty of large construction projects. If you have a well-structured schedule that everybody works to, it can be of great benefit to a project, and as it has been on this particular project.

Now that a clear value stream has been identified and implemented, the short-term future plan is to continue utilising the Lean principles used in this improvement project for all of our other modular wiring construction zones on this project. Our intention is to continue to look for improvements and wastes at every opportunity within all processes going forward. This new process will now be communicated across the company to utilise this Lean Win.

Company Overview | Suir Engineering | suireng.ie

Established in Ireland in 1984, Suir Engineering is an Irish-based European provider of Mechanical & Electrical services to high profile clients in the data center, life science, manufacturing, commercial, and substation and renewables sectors.

Suir Engineering has offices in Dublin, Waterford, Sweden, Denmark, London, and across the UK, directly employing over 1,000 highly skilled staff. Having recently celebrated 35 years in business, Suir Engineering has developed a reputation for delivering cost-effective solutions for its clients whilst ensuring an uncompromised approach to safety, quality, and project delivery. Suir Engineering is part of the EDF Energy Services group of companies.

Author

Sean McHugh

Overview & Background to the Lean Initiative

Since 2015, Suir Engineering has continuously increased its investment in its strategic and company-wide improvement initiative entitled "Suir Way". Since April 2018, Suir has been rolling out new processes for managing the entire organisation. Suir Engineering has invested heavily in its employees by providing a significant amount of off-site and on-site training, and has developed its own purpose-built training centre at its Dublin location.

Thanks to the company's investment in its people, it is now seeing a transformation within the business: employees are using their new skills on projects of all sizes to remove the eight wastes; introduce JIT for site deliveries; run Kaizen events; value stream map processes; utilise look-ahead planning based on the LPS; apply 5S and Kanban systems to site stores; and develop standard work.

These tools are being driven by Suir Engineering's management system that promotes discussion, is data-driven, and ensures the correct and relevant information is channelled through the business, thus empowering everyone from the SLT, project managers, supervisors, and trades, to make informed decisions with all the necessary information.

In the LCi Book of Cases 2018, Suir Engineering's case discussed the improvements being made around how it managed materials and waste with the implementation of 5S and visual management. In the LCi Book of Cases 2019, Suir Engineering's case discussed how it was developing its new on-site management system "The Suir Way" and how it was allowing the capture of information and for that information to flow smoothly throughout the organisation.

This 2020 case illustrates the progression of Suir Engineering's Lean journey and showcases how employees did not simply show up for training, but have embraced the idea of Lean and the Suir Way. The organisation has gone from implementing small and isolated Lean ideas and projects to being able to implement big Lean ideas and utilise Lean tools on large scale and high-profile projects.

Lean Initiative Undertaken – Lean Thinking, Tools, Techniques

Suir Engineering rolled out this Lean project on a large-scale pharmaceutical project in the north east of Ireland. Once complete, the project will be the largest pharmaceutical facility of its kind in the world. Suir Engineering is responsible for the Electrical & Instrumentation package, design-assist, testing, and commissioning, along with the temporary electrical package for the project. The project started in April 2019 and is expected to be complete in December 2020.

At the time of writing, Suir Engineering has 10 supervisors who manage 180 direct personnel on the site. With that many direct staff to manage, a Lean approach was required towards the assignment of tasks and how materials and resources would be managed on-site. In doing so, it would help to ensure that key milestone dates would be achieved and that issues and constraints could be raised and rapidly resolved at the correct level of the business.

Tier 4 Meetings

Each Suir Supervisor installed a Tier 4 (T4) meeting board in the work area they were responsible for (Figure. 1). The supervisors ran daily meetings at the workface at the start of each shift, at which everyone is made aware of what is expected of them for the day, issues and constraints are identified, safety watchpoints are highlighted, along with quality or coordination.

Figure 1. Tier Board & Meeting On-Site

On-Site Material Management

Material that is required to be brought to the area is also arranged. Planning is a key part of the T4 board and 2-week look-aheads are issued and monitored with the supervision to gauge plan adherence and to highlight any issues/ delays. In order to reduce the time spent getting material in stores, small material workbenches were brought to the work area. This was implemented along with the reduction in time spent by employees travelling to and from stores, the materials benches also incorporated a Kanban system allowing material shortages to be managed effectively and to highlight when materials were low.

Suir Engineering also ensured that BIM stations were available at each level of the facility. This was to allow trades and supervision have the most up-to-date information, empowering them to make decisions in the field and correctly sequence work. When the BIM stations are not in use, they automatically switch to play SOP and safety videos to enforce the safety culture on site (Figure. 2).

Figure 2. BIM Systems Used to Promote Safety When Not in Use

Tier 3 Meetings

The Tier 3 (T3) meeting is a focal point of the day and has been run successfully throughout the project. The Suir team has been fully engaged in the T3 meetings where conversations are open, honest, and to the point. The Project's Construction Manager chairs the meeting and ensures the conversation remains on topic and the meeting keeps pace. The meeting is attended by site supervision, store manager, safety lead, QA lead, lead planner, site admin, QS lead, and project director.

Tracking of Downtime Reworks and Covid-19 Issues

Obtained directly from the workface T4 boards, information flows freely on the site and is passed on and discussed with the site management team at the T3 boards. This allows for a lot of valuable information to be tracked in real-time. This has allowed the team react to issues that have arisen on site more quickly than they would have previously. This also allowed them to try different approaches and get feedback as to how it is working within 24 hours. This feedback has been invaluable as the team try and navigate through Covid-19, allowing the team to experiment with different approaches and help maintain productivity whilst also ensuring that employees are kept safe.

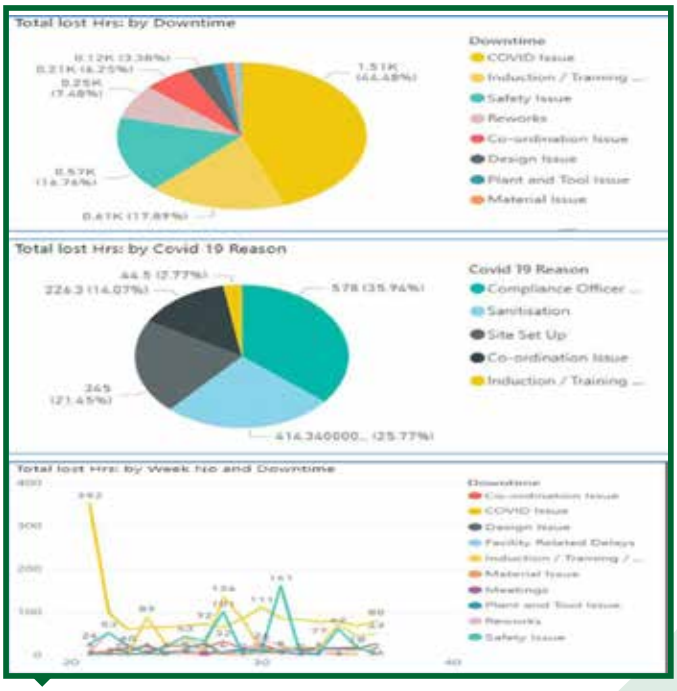

Figure 3. Downtime Tracking & Analyses

Quality – First Of Kind Wall

As with all Suir projects, quality plays a key part in our process. On-site, the team has implemented a "First Of Kind (FOK)" Wall to enable staff to review client and Suir expectations around install standards. This FOK Wall is on route to the workplace and sets the expectations around install standards for the staff. The wall has become part of the induction process for Suir Engineering. Everyone, regardless of their position in the company, understands what is the site standard. Even though containment only covers 15% of the overall job, traditionally it accounts for over 70% of site snags. With over 80% containment now complete on-site, the benefits of the investment can be seen with little-to-no containment issues identified in walk-downs.

Figure 4. First Of Kind (FOK) Wall

Stores Set-Up & Workplace Organisation

5S has been implemented to a high level on site. This means walkways are clear and materials are segregated and clearly identified, thus reducing time lost looking for materials and making it easy to establish stock volumes.

Figure 5. 5S Workplace Organisation

Just In Time Deliveries

Just in Time (JIT) deliveries were planned and coordinated with ceiling install and floor finish dates for all modular wiring so it could be delivered directly to the relevant floor. As a result, Suir Engineering benefitted from a simplified and accelerated installation process, whilst the client received a flexible, future-proofed, and cost-effective installation. Due to the lack of laydown space on site, the team utilised staggered deliveries arranging bulk orders with agreed call-off dates with suppliers. Bulk ordering has minimised the number of requisitions from site and also improved buying power for the project.

Lean Initiative Improvements & Impact

Suir Engineering has seen real tangible improvements since it began its Lean journey. These improvements had previously been small in scale and involved a limited number of individuals. The ability to implement multiple Lean construction ideas and teachings on a large-scale project was something that had not been previously realised until this project. The task of implementing Lean into a company is often referred to as a "Lean Journey". This phrase was perhaps not fully understood by the Lean Team when they first set out to bring Lean into Suir Engineering. Lean is a journey with many highs and lows. It cannot be brought into an organisation overnight. To make meaningful change is more than just training staff in new rules and processes and expecting them to comply. Thanks to Suir Engineering's investment in its people, and its high staff retention levels, most employees are now on their second or third site on which Lean initiatives have been implemented – they are now experienced Lean practitioners.

It is not only the company that has gone on a Lean journey, but the staff of Suir Engineering have also gone on their own personal Lean journeys. This has enabled them to see what has and has not worked on other projects. Everyone is now able to see the bigger picture and how small changes to their work practices can have major impacts to the overall project. The T4 and T3 boards have provided trades, supervision, and management with a shared platform to voice concerns and have them resolved in real-time and collaboratively.

Some of the key learnings from Suir Engineering's journey have been:

- People support what they create – By allowing staff the ability to voice and implement their ideas, you will get much better buy-in when they are part of the creative process.
- Encourage small ideas from all levels – Small improvements have enormous compounding effects over time and can be easily shared and implemented on other sites.
- Structure is key – A system to allow information to flow and people know where to get the correct information.

Key benefits from the implementation of Lean on the site:

- Increased planning of works –This focus on what needs to be in place before work starts has greatly improved workflow.
- Reduced Requisitions – A direct outcome of better planning has enabled the team to reduce the number of requisitions raised. This has relieved the pressure of the purchasing team. At present, and despite being one of the largest projects for Suir Engineering, the project raises far fewer requisitions then that of considerably smaller projects.
- A 60% reduction in modular wiring and lighting install – By engaging early, using the LPS and JIT delivery methods, Suir Engineering was able to achieve significant cost savings.
- Reduction in snags and rework – Utilising the FOK walkdowns has resulted in little-to-no rework or snags being produced.
- Improved Engagement – Staff morale has increased and employees feel valued.

SUIR ENGINEERING

Company Overview | Jacobs | jacobs.com

Jacobs

Jacobs leads the global professional services sector, providing solutions for a more connected, sustainable world. Headquartered in Dallas, Texas, with approximately US$12 billion in revenue and a talent force of more than 50,000, Jacobs provides a full spectrum of services including scientific, technical, professional, construction, and program management for business, industrial, commercial, government, and infrastructure sectors. Marking 46 years in Ireland, Jacobs established its first international office outside the USA in Ireland in 1974. Today, the company employs more than 1,100 people across Dublin, Cork, and Belfast.

Author

Greg Moran

Overview & Background to the Lean Initiative

Covid-19 continues to have a dramatic impact on the way we work in our industry. Unsurprisingly, it has also had an effect on how Lean thinking and practices are being deployed on Jacobs' projects worldwide. This case study – which is anonymised for confidentiality reasons – shares some of the approaches and solutions that Jacobs is using to minimise disruption to the deployment of Lean thinking and tools on our projects, whilst also continuing to optimise their benefits. It is worth noting that while Covid-19 has caused disruption, there have been some positive aspects, primarily with the shift towards remote working accelerating the integration of digital tools and ways of working.

Lean Initiative Undertaken – Lean Thinking, Tools & Techniues

Last Planner® System Thinking & Behaviours

The Last Planner® System (LPS) is probably the most recognised and established Lean practice in the AEC sector worldwide. LPS is a foundational Lean technique that often enables further deployment of Lean thinking and practices within projects and organisations involved in the AEC sector. The primary benefit associated with the successful deployment of LPS is reliable workflow. This enables projects to adhere more closely to agreed schedules and increases the likelihood of them being completed on time. LPS succeeds in enabling more reliable workflow because its deployment unlocks important behaviours and ways of thinking associated with successful collaboration and project delivery, including:

- Higher levels of engagement from trades and disciplines during the planning process. This results in a higher level of shared ownership for the work plans. The teams are more committed because they are engaged and invested in the process.
- Meaningful collaboration between all stakeholders. This includes teams displaying a greater willingness to make requests of other teams or disciplines for things they need to progress their own work, while in turn making firm commitments around tasks that they themselves can deliver. This leads to greater levels of transparency and collaboration compared to teams that do not subscribe to the principles of LPS.
- LPS promotes higher levels of trust across teams. Trust does not emerge in a vacuum, but rather grows where reliable promising exists – a characteristic that is encouraged within the LPS framework. If an individual consistently meets their promises, they become trustworthy. The same thinking applies to trades or disciplines.

• Rather than ignoring constraints – issues that have the potential to prevent work progressing to plan – LPS encourages proactive identification of, ownership for, and removal of constraints. Constraint logs are often employed to support this aspect of LPS deployment.

• Learning and Improvement – the simple process of capturing and categorising the main root causes for failed commitments that is embedded into LPS encourages teams to move beyond blame-oriented behaviours ("who") towards learning and improvement ("why").

• Shared Understanding of Flow and Pull – the closer collaboration that LPS deployment encourages creates a better understanding of the importance of the Lean principles of flow and pull for all parties. These Lean concepts become less abstract, and it becomes more evident to all that having one discipline or trade getting significantly ahead of others can create queues and waiting waste elsewhere.

LPS has become an increasingly prevalent Lean practice within Jacobs' Life Sciences projects worldwide. There is growing recognition within Jacobs and among our client base that LPS deployment yields significant benefits during design and construction phases. On a recent life sciences project, the Jacobs construction management team, together with all key contractors on-site, successfully implemented some of the core principles underlying LPS in a manner that was working well and yielding benefits prior to the emergence of Covid-19. The challenge for the project team was to successfully migrate some of the LPS practices on the project to remote working, without diluting any of its key benefits, following the adoption of social distancing measures and new working practices necessitated by Covid-19.

Adapting Last Planner® System Implementation to Covid-19 Challenges and Remote Working

• Digital Weekly Planning & Lookahead Meetings – A key element of LPS implementation is the weekly planning and lookahead meeting. Pre-Covid-19, this meeting was a traditional face-to-face meeting attended by the Jacobs construction team and representatives from all project contractors engaged on-site. The meeting has since migrated to a virtual meeting format using Microsoft Teams to ensure compliance with social distancing measures. Weekly results and production plans are now generated via Teams to enable the weekly PPC% to be generated and shared virtually in real-time during the Teams meeting. Team commitments are discussed, made, and captured virtually via shared screens during the meeting. The weekly and updated lookahead plans are issued from Teams shortly after the meeting is concluded. Root causes of failed commitments are also categorised and issued as part of the output of the virtual meeting.

• Digital Pull Planning Meetings – Jacobs has also begun to host virtual pull planning meetings as part of the migration to digital LPS deployment. Previously, pull planning meetings were held in a traditional format with all team members attending in a meeting room using Post-its to identify upcoming milestones and the various tasks required to meet them on time.

Figure 1. Example of Virtual Pull Planning

Jacobs is now employing a number of digital tools to support virtual pull planning meetings, including Nureva and Mural, with good levels of success.

• Lessons from Digital LPS – The changes to the LPS practices outlined above have been successfully implemented in the context of the wider changes on sites and in working practices necessitated by Covid-19. The migration of these LPS practices to remote working has been achieved without significantly affecting performance levels, as reflected by the PPC% trend in Figure 2.

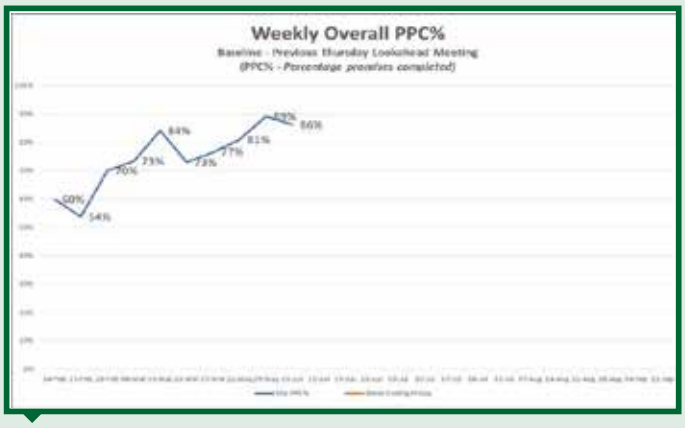

Figure 2. PPC Trends

Lean Initiative Improvements and Impact

Digital and General LPS Benefits

As outlined earlier, the most significant and tangible benefit of LPS deployment is around workflow reliability. The PPC% metric is employed within the context of LPS to reflect the level of workflow reliability. It can be helpful to think of the metric as percentage promises completed rather than just percentage plan complete). The metric does reflect the degree to which the team is making reliable promises.

A significant improvement in the PPC% level – from a baseline of less than 60% to 85% levels – was achieved from the time the team started tracking and focusing on the metric on one of the life sciences projects examined. This PPC% improvement reflects the ability of the whole team to collaborate effectively and to make reliable promises to each other.

As outlined earlier, our experience is that PPC% improvements are brought about by changes in the underlying behaviours that LPS deployment encourages and enables. These subtle behavioural shifts underlie any PPC% improvements realised.

In the case of this project experience, these behavioural changes included:

- More focused and effective collaboration between all stakeholders and contractors, brought about by all parties focusing on a single shared result, namely the PPC% level.
- Clarity – The simplicity and value of the single and memorable result, namely PPC%, that communicates a simple, meaningful result to all stakeholders involved in delivering work should not be underestimated.
- Plan ownership and accuracy – LPS enables all stakeholders to participate in generating short-term plans. This not only creates ownership but also accuracy as plans are based on the most recent information available.
- Behaviours – Specific behaviours the LPS process unlocks include:
  - Encouraging the making of reliable promises in a blame-free environment.
  - Making specific requests of others to enable work to progress.
  - Improvement focus by identifying root causes of failed commitments as opposed to allocating blame.

Additionally, the team began to track the primary root causes underlying failed commitments. The purpose was to focus on the underlying reasons – the "why" as opposed to the "who". Using this information to avoid making the same mistakes twice also contributed to the improvement.

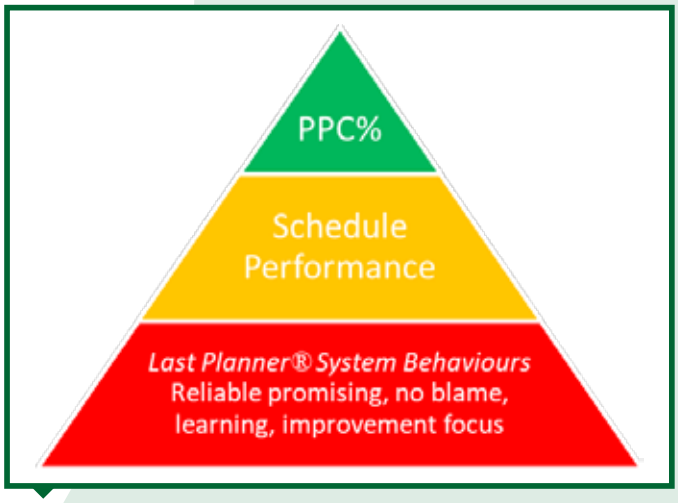

Figure 3. Last Planner® System Behaviours and Results

The key conclusions are:

- LPS has yielded significant benefits in the Jacobs life sciences projects on which it has been deployed to date.
- Where teams cannot meet and engage face-to-face due to Covid-19 restrictions, it is possible to adapt some of the elements of LPS deployment to remote working by using a variety of digital tools.
- To date, the migration of elements of LPS to digital tools and remote working has not resulted in any noticeable dilution of the associated benefits.
- The fact that the deployment of LPS was reasonably well-advanced prior to the onset of Covid-19 and the implementation of the associated restrictions has helped the successful migration towards digital tools and ways of working.
- Covid-19 has accelerated the deployment of some digital tools that support digital working and digital LPS deployment.

Company Overview | John Paul Construction | johnpaul.ie

John Paul Construction is a leading building and civil engineering contractor with a long-standing reputation for integrity, professionalism, innovation, and excellence. With more than 70 years' experience across all sectors of the construction sector, our success is built on an uncompromising dedication to quality and service.

We put our Clients' interests first, providing a level of service that enables them to concentrate on their business in the knowledge that their project is in safe hands. One of our key strengths is our ability to forge strong partnerships and long-lasting relationships across clients, professionals, and supply chain. We are owner-driven and passionate about our work, with a hands-on collaborative approach and genuine commitment to delivering value and excellence in everything we do. Construction is all about people and performance, and our people are skilled and highly-trained with the experience and ability to deliver the most complex and challenging projects within demanding project deadlines and meticulous quality standards.

Authors

Niall O'Donoghue

Michael Kelly

Overview & Background to the Lean Initiative

As turnover levels increased, and as the demands on all levels of management and subcontractors increased, John Paul Construction recognised that improved efficiencies, including methods of short-term planning, was required on sites. This requirement was also heightened with the undertaking of fast-track projects due to demands by clients to reduce durations on site and deliver projects in an accelerated manner due to their business-driven deadlines.

As part of our approach to meet these demands and improve sustainability and efficiencies for our clients, John Paul Construction has adopted Lean principles and our Lean initiative commenced with the introduction of the Last Planner® System (LPS) across a number of projects. Training in LPS, which was supported by Enterprise Ireland, was introduced across various projects, including: a residential development, a city centre hotel development, and the Lidl Regional Distribution Centre (RDC) in Newbridge (entitled "Newbridge 2").

In addition to LPS, which was utilised on Lidl, we also used our relationship with the client which was developed at tender stage to openly and collaboratively challenge the tender design through detailed Value-Engineered proposals. The purpose of these proposals was to introduce proven Lean initiatives utilised on a range of industrial projects undertaken by John Paul Construction that were proven to reduce waste, improve the project schedule, and increase off-site fabrication to bring an overall increase in on-site efficiencies and assist the team in delivering the project.

This case study explores some of these Lean initiatives that secured the contract for John Paul Construction and successfully delivered the project on time and on budget with minimal defects.

Lean Initiative Undertaken – Lean Thinking, Tools, Techniques

As the single largest investment by Lidl in Ireland, "Value from the Customer's point of view" on Newbridge 2 not only encompassed the delivery of the project on time and on budget, it also provided an opportunity for the Irish Construction team within Lidl to showcase to their Lidl International colleagues the added value that real collaboration between designers and contractors can deliver when given the opportunity to do so.

John Paul Construction therefore recognised at tender stage that the Irish team within Lidl had to deliver tangible results of a Lean approach to building, and that investing energy and deploying resources into challenging the status quo from the earliest planning stages of the project to drive Lean thinking would be like "pushing an open door" and not set the contractor and designers on an inevitable route to conflict. It was therefore clear from the outset that all stakeholders – Client, designers, contractors, and suppliers – were open to collaboratively delivering value by identifying and driving the Lean processes and techniques that would be deployed to deliver this value.

First and foremost, it is important to understand the project was all about scale and that marginal improvements had the potential to deliver real and tangible gains in the same way wasteful or inefficient practices are magnified to the detriment of a project and its commercial performance.

Figure 1. "One Project Approach"

Scope of Works

The works comprised the construction of:

- A new build high-bay warehouse building with a gross floor area (GFA) of 58,032 m2, including:
  - Warehouse element maximum parapet ridge height of c.17.9m and overall dimensions of c.124m in width and c.437 in length.
  - 20,068m2 of temperature-controlled storage chabers, ranging from a 4,300m2 "-24o freezer" to a 6,000m2 fruit and vegetable storage facility.
  - High bay and dynamic racking to "ambient" cross-dock warehouse space.
  - Associated mechanical and electrical services.
  - Two high-specification finished administration buildings (1,790m2 GFA and roof height of c.10.6m).
  - 154 Dock Levellers.
- Earthworks enabling package:
  - 370,000m3 bulk earthworks.
  - 330,000m3 lime and cement stabilisation.
  - 4.2km Tubosider drainage system (1400mm diameter).
- 80,000 m2 of external concrete truck parking and services yards.
- 300 car parking spaces.
- Largest building-mounted photovoltaic array in Ireland comprising 4,364 panels capable of generating over 1-million kWh hours per annum.

Works were scheduled to commence in September 2018, and the brief called for the facility to be delivered by October 2019 to meet peak Christmas demand and provide appropriate additional warehousing space for Lidl to store stock in order to address uncertain Brexit outcomes.

Across four areas – Groundworks, Facilities, pecification, and Sustainability – the programme targeted delivering:

- Groundworks: An engineered design and build ground treatment solution to provide a suitable platform on a site with poor natural ground conditions to construct the warehouse.
- Facilities: A curtailed transition period between construction and operations by integrating Lidl IT, its network and order picking systems, as well as mechanical handling equipment deliveries into the main build programme.
- Specification: A "head office" specification administration block for staff and a warehouse building that met Lidl International design standards.
- Sustainability: One of the most sustainable and energy-efficient logistics centres in Europe with A1 energy rating and BREEAM Excellent Standards in design and construction.

Projects of scale, with many duplicated details, demand a production mindset to deliver consistency and avoid rework, and thus a Lean approach is tailor-made for this kind of project. The strategy deployed by John Paul Construction during early planning was to explore and deliver on marginal gains in every work package, and to understand and mitigate project risk through careful planning and contingency planning.

From early planning stages during the tender, technical and commercial risks and opportunities were identified and recorded in live registers from detailed interrogation of the works requirements, multiple visits to recently completed RDCs in the UK, and knowledge sharing with supply chain partners, many of whom had worked on similar Lidl Projects in the UK and Europe.

Ultimately Lidl would have the final say in relation to all initiatives identified; however, the following schedule identifies some of the technical efficiencies delivered by our Project Team through deployment of Lean thinking from the outset:

- Project acceleration to mitigate delays incurred pre-commencement on-site.
- Groundwork strategy that eliminated off-site disposal in favour of treatment and reuse on-site.
- Overall review and redesign of drainage, foundations, structural steel, and roofing to reduce quantities, improve installation efficiencies, and provide an overall cost and programme benefit to the project.
- Early selection of pre-lagging mechanical and refrigeration pipework, and off-site lagging of refrigeration plant, significantly reduced the typical refrigeration commissioning periods.
- Increased off-site assembly of electrical, mechanical, and sprinkler components to accelerate first-fix works.
- Utilising pre-fabrication for walls and buildings where possible to improve installation times.

- Use of Revit and 3D planning to create "no fly zones" through high-level services to aid access and future maintenance.

Tools Deployed to Deliver the Lean Approach

Viewpoint

The entire project team used Viewpoint as a Common Data Environment (CDE) for the sharing and dissemination of all information and project records, with bespoke workflows established from the beginning of the project for technical submittal approval processes, benchmarking process, and the tracking of RFIs. This ensured fast-track production could proceed on a large scale with a clear understanding of acceptable standards and performance metrics.

Fieldview

This is a cloud-based and off-line mobile solution that replaces pen and paper in the field, and it was used by the entire team for inspections, including: safety inspections, quality observations (both good and bad), BCAR inspections, snagging, technical queries, benchmarking, and sample approvals to track and close-out issues as they arose. Having single portals for tracking actions and sourcing information proved vital to the delivery of such a large-scale fast-track project.

LPS

For short-term planning and scheduling works on site, we utilised LPS which is a well-established and trusted collaborative planning system used across multiple John Paul Construction sites and which focuses on better short-term planning by all the stakeholders involved in the delivery of specific tasks.

LPS training was arranged early in the contract for the entire supply chain, and was delivered by Lean Touch Solutions Ltd who were brought on board to review the specific needs of Newbridge 2 and support the team. Additionally, an on-boarding workshop was given to the senior team to give a high-level overview of the Lean programme and explain the phases and elements of the LPS programme. This set the LPS vision among the senior stakeholders on the project and allowed the team to develop a Lean implementation plan for Lidl. Following the on-boarding, Lean Construction and LPS training was provided to the senior members of our team along with the key personnel from the key subcontractors who were working on the project. Our commitment to providing this training, along with the subcontractors' commitment in terms of attending the training days during the start of a fast-track project, demonstrated the entire team's intent in ensuring that LPS would be implemented on site.

Due to the scale of the Lidl project, the LPS was implemented in a twin approach with separate pull plans prepared for the civil works and the building works. The project managers for each section worked with Lean Touch Solutions and the subcontractors to generate the initial Pull Plan and agree the key milestones for each section. Crossover points between the building and civil works were managed by regular communication between the team leaders. The implementation of regular meetings and huddles to facilitate the pull plans, weekly planning sessions, and daily huddles was a challenge, but all members of the team, with continued support and training from Lean Touch Solutions, ensured that the system was bed-in over a period of time to allow it to assist in bringing a successful outcome on the project.

Figure 2. LPS Meeting

Overall, the implementation of LPS on Newbridge 2 improved schedule accuracy, cost control, quality and health and safety.

BIM

John Paul Construction employed several digital tools to manage the different aspects of the project. A client requirement called for the project to be delivered in line with the Fundamental Principles of Level 2 Information Modelling stipulated within PAS1192-2:2013. We thus produced a model production delivery table (MPDT) at the start of the project to plan out the BIM model delivery. This defined who was responsible for each element of the model and to what level of detail they were required to develop. This was continually updated throughout the project and mapped the model development from stages 3 (Developed Design) through to stage 6 (As-built and handover).

The fully integrated, coordinated, and up-to-date BIM model allowed the site team to accurately set-out all elements from the model, to generate live as-built records, and to use tablet applications such as "Dalux Viewer" to compare virtual views of the planned installation against actually completed works. The approach to BIM delivery was recognised by the Lidl design team (who work on many similar projects across the UK for Lidl) who acknowledged that the John Paul Construction approach went beyond anything they had seen to date from main contractors in the UK.

Figure 3. BIM Example

Drone Technology

A heavy reliance on drone technology aligned with the BIM model, allowed John Paul Construction to manage bulk earthworks in real-time and eliminated disputes with subcontractors over measures and quantities of materials placed on site. The drone survey footage was processed within "ReCap Photo" to produce a point cloud of the site each week, and these point cloud surveys were used for a cut-fill analysis of works completed. A site-wide drone fly-around was undertaken once a week, and this footage was utilised for project reporting and works quality, as well as for client meetings reviewing works ongoing and completed.

Figure 4. Completed Project Exterior View

Lean Initiative Improvements & Impact

Newbridge 2 was delivered on budget and on time as a direct result of the Lean approach adopted by John Paul Construction from the earliest planning stages of the project. It was an immensely satisfying project to work on, where everyone from the client and design side, to the contracting team and supply chain pulled together and rose to every challenge with a level of professionalism and control that ensured the quality of the end-product was never compromised.

Standout features that contributed to the successful delivery of Newbridge 2 include:

- The pre-eminence of the Project-need over individual self-interests, allowing design intent to be interrogated in favour of more efficient solutions.
- The implementation of LPS which was led by our project managers and implemented by the supply chain to bring efficiency to the project schedule.
- The commitment to BIM execution and standardised project systems that helped streamline the flow of information between design and operations.
- The synergies achieved between the JPC Civil's team and the Main Build team allowed the envisaged enabling works lead time to be considerably reduced to preserve the end date.
- Selecting a familiar supply chain with a proven track record in collaborative fast-track industrial facilities and creating an environment on-site that could leverage their expertise to optimise the delivery of the project and meet the onerous project completion milestones.

Figure 5. Completed Project Interior View

Project Testimonials from the client and design team speak to the collaborative approach and use of Lean thinking and practices from early stage through to handover.

Lidl (Client):

"The entire project was designed, coordinated, planned, and installed using BIM. This approach provided an invaluable tool to both the design and delivery teams in early clash detection and avoidance, and also ensured that the building successfully met and exceeded our requirements. Their delivery team executed the works in a very efficient, professional manner and to a high quality and standard whilst fully engaged to successfully deliver a BER A-rated warehouse, BREEAM Excellent, and full validation of BCAR."

JV Tierney & Co (Services Consultant):

"John Paul Construction's task was to coordinate, construct, and commission the Distribution Centre to operational specification within 12 months. John Paul Construction achieved this with a collaborative approach to the project. They enacted on-site policies to ensure good communication between all stakeholders and the use of BIM to enable off-site fabrication, thus ensuring a quick and safe installation on-

required of the building services, including sprinkler protection integrated into the racking and waste heat from the temperature-controlled areas linking to the heating system. John Paul Construction also incorporated late instructions for additional works into the building programme. The 1.2 MegaWatt Solar PV installation is a good example of this, and it is the largest rooftop PV array in Ireland."

From the above testimonials, it is clear that our adoption of a Lean Approach to Newbridge 2 delivered on its value commitments to the Client, collaboratively challenging established construction details across the work packages, coordinating the works effectively using the latest digital tools to minimise waste, supporting off-site innovation, and using production planning tools and quality control systems to deliver the project on time and to the necessary quality.

John Paul Construction believes that it is possible and necessary to continuously improve processes and eliminate waste in lines with Lean philosophy.

PAUL

Company Overview | Collen Construction | collen.com

Established in 1810, and trading as "Collen Bros." until 1984, Collen Construction is one of the leading construction firms in Ireland, and we are extremely proud of our history and reputation for building quality and excellence. The company offers a full range of construction services, including management contracting, design and build, joint venture/partnering, and turnkey contracts. We have experience in a variety of project types, including residential, commercial, educational, retail, data centres, leisure, health, pharmaceutical, industrial, and conservation, and ranging in value from under €1Million to in excess of €300Million. We have longstanding relationships with numerous Clients and Consultants built up over the years, ensuring the company has remained at the forefront of Irish construction for two centuries. Our Client list is testament to the excellent service the company provides on every project.

Author

Willie Loughnane

Overview & Background to the Lean Initiative

The culture of continuous improvement within our day-to-day operations at Collen Construction means that our organisation continuously strives to exceed our clients' expectations through the adoption of new and innovative Lean practices. The successful delivery of large and complex builds depends largely on the rigorous and systematic approach to scheduling – a tactic that Collen embraces from project initiation stage right through to project handover. This culture empowers our project delivery teams to challenge the status quo and make the best plans even better.

The first area of focus for planning improvements centres on the implementation of a RAID (Risks, Assumptions, Issues, Dependencies) log at our weekly LLP (Lean Last Planner) sessions. The volume of critical information being shared by all project stakeholders at these planning workshops was proving to be very beneficial, but we needed a platform to capture and analyse these constraints to drive confidence with our decision-making. Additionally, the decision to enhance our Project Controls procedures through the adoption of the PDCA model further strengthened our ability to deliver these complex projects on time every time.

Lean Initiative Undertaken – Lean Thinking, Tools, Techniques

Over the last number of years, Collen has been implementing the LLP tool on a high percentage of our fast-track projects with great success. Our commitment to the Kaizen philosophy means that we are constantly in pursuit of operational excellence, striving to find possible areas of improvement to further enhance our embedded Lean Construction tools.

One area that we decided to focus on over the last 12 months was to further enhance our Last Planner® System (LPS). Typically, we would hold a full day LLP session with all project stakeholders at the start of a project to build-out the master schedule through open collaboration in an environment of trust and support. At these events, the exchange of crucial information between the project stakeholders was proving to be a valuable source of information and the open engagement fostered a platform for discussions on project specific risks, assumptions, issues, and dependencies.

As useful as these sessions were for validating and enhancing the project schedule, we identified through a plus-delta exercise that the opportunity to capture other key project nuances was being missed. It is only after the completion of a typical LLP session that the project team 'deep dive' the information gathered and sieve through the swarm of challenges that each stakeholder presented on the day. The ensuing question related to how all of that information was going to be managed. We needed to incorporate a method of capturing and tracking these project constraint items along with the strategies and action plans to fix them. Instinctively, we decided to implement the RAID log as a parallel tool for the project manager to track the following: Risks, Assumptions, Issues, Dependencies. Identifying these early in the project was going to help us to assess all of these RAID components and act accordingly. Avoiding them could

could cost us or even derail our projects completely.

The opportunity to implement our RAID methodology evolved when we held our first day-long LLP session for a new €50M commercial project in South Dublin that we had recently been appointed as Main Contractor. This complex build was at its initiation stage, providing the perfect time for this Lean implementation. This holistic approach to project planning together with the project stakeholders was held off-site in a conference room in a nearby hotel, providing a comfortable and distraction-free environment for problem solving and open collaboration. The partnership approach with our supply chain enabled a seamless introduction of the RAID log and empowered all teams to contribute to the continuous improvement of our LPS.

The objective of this RAID was to essentially capture all Risks, Assumptions, Issues, and Dependencies that arose during the LLP session, with specific emphasis at the interface zone of the various subcontractor packages. As the various discussions on task sequencing and execution plans played-out, the resultant RAID components were recorded on a shared Master Log (Figure 1) and categorised as follows:

- **Risks** – Any discussion item that had a level of uncertainty, which if materialised, could have impacted the project deliverables or outcomes negatively.
- **Assumptions** – Factors that were assumed to be true were categorised here. These included items whereby subcontractors based their planning on previous experience and historical situations. However, it was vital that the critical assumptions were captured for if they turned out to be invalid, they could have a detrimental impact on the project outcome.
- **Issues** – Items that needed to be resolved and an agreed strategy to get there as soon as possible. We needed to track and monitor these items to mitigate against any roadblocks and/or delays in the workflows.
- **Dependencies** – These were the tasks that were dependent on the completion of other tasks (make-ready) by other trades, ensuring a smoother workflow at the coal-face for task execution.

Our project team's experience and expertise enabled us to identify the correct category for each RAID component, prompting the next step of evaluating their criticality, actions to reduce their likelihood/impact, and assignment of responsibility along with due dates.


RAID Analyses

collen 200

Project

Key Risks, assumptions, issues, and dependencies

No.	Description	Type	Criticality	Next Actions	Owner
1	[illegible]	Risk	Medium	Aircraft to follow up on tied in time	[illegible]
2	[illegible]	Risk	Medium	Design to be followed up on.	[illegible]
3	[illegible]	Risk	Medium	Collen team to follow up with supply chain	[illegible]
4	[illegible]	Risk	Critical	CCL/ GDC to look at this detail closely and formulate a QA/QC procedure on this particular element	[illegible]
5	[illegible]	Risk	High	Further schedule needed at level 2/ level 3 planning stage	[illegible]
6	[illegible]	Risk	High	Aircraft to confirm tied in time order	[illegible]
7	[illegible]	Risk	Critical	Needs further analysis at level 2/ level 3 planning stage	[illegible]
8	[illegible]	Risk	High	DLIG: Meter to confirm	[illegible]
9	[illegible]	Risk	High	Resource requirements to be closely monitored at level 2/ 3 planning	[illegible]
10	[illegible]	Risk	High	Resource requirements to be closely monitored at level 2/ 3 planning	[illegible]
11	[illegible]	Risk	High	Aircraft to follow up	[illegible]
12	[illegible]	Risk	High	Design to be tracked	[illegible]
13	[illegible]	Risk	Medium		[illegible]
	[illegible]	Risk	Critical	Critical path activities to be closely monitored here	[illegible]
14	[illegible]	Assumption	Medium	Exact point of partial install to be confirmed	[illegible]
17	[illegible]	Assumption	Medium	GDC to street	[illegible]
18	[illegible]	Assumption	Medium	GDC to confirm	[illegible]
17	[illegible]	Assumption	Medium	GDC to confirm	[illegible]
18	[illegible]	Assumption	Medium	Detail to be finalised between GDC/ CRONIN/ DLIG	[illegible]
19	[illegible]	Assumption	Medium	CCL to assess	[illegible]
20	[illegible]	Assumption	Medium	DLIG to confirm	[illegible]
20	[illegible]	Assumption	Medium	CTH to confirm	[illegible]
22	[illegible]	Assumption	Medium	To be further reviewed at level 2/ 3 planning	[illegible]
23	[illegible]	Assumption	Medium	D/ A	
24	[illegible]	Assumption	Medium	D/ A	
25	[illegible]	Assumption	Medium	CCL to follow up with planning consultants	[illegible]
26	[illegible]	Issue	Medium	RFI with DETEC	[illegible]
27	[illegible]	Issue	Medium	RFI with DETEC	[illegible]
	[illegible]	Issue	Medium	To be coordinated at level 2/ 3 planning	[illegible]
28	[illegible]	Dependency	Medium	Liaise with TDA	[illegible]
29	[illegible]	Dependency	High	GDC/ CRONIN/ ALUCRAFT to coordinate and confirm detail sequence of install	[illegible]
30	[illegible]	Dependency	Medium	Monitor completion date of CW scope to flag completion of start clashes	[illegible]
31	[illegible]	Dependency	Medium	Approve package to steel contractor	[illegible]
32	[illegible]	Dependency	Medium	Cover trenching tender needed	[illegible]
33	[illegible]	Dependency	High	Materials to confirm, resources to be monitored	[illegible]

Figure 1. Master Project RAID Log

Project Controls

In recent years, Collen has successfully carried out a significant number of fast-track, multi-million euro projects across Ireland and Europe. The schedules associated with these complex builds have become more and more demanding, highlighting the need for further enhancements to an already robust project controls mechanism within the organisation. With a strong continuous improvement culture embedded, Collen looked towards the PDCA (Plan-Do-Check-Act) cycle (Figure 2.) to augment our schedule management procedure with the aim of mitigating against schedule slippage and to de-risk all projects from costly delays. Using the PDCA model, we incorporated a step-by-step process at project management level, providing a platform as a single source of truth for Schedule monitoring. This tracking tool incorporates:

- **Plan** – Enhancements made through identifying the key project milestones and detailed six-week look-aheads incorporating a mechanism for forecasting the start and finish dates for critical activities.
- **Do** – Follow through on the critical requests for further information (RFI), submittals, package procurement, and execution of construction tasks.

- **Check** – Introduced robust monitoring of all the project KPIs including APC (Actual Percent Complete) Vs PPC (Planned Percent Complete) for all site activities, SPI (Schedule Performance Index) trends, Subcontractor performance, Schedule variance analysis, and Schedule risk analysis.
- **Act** – Prompts focus on mitigation measures and corresponding action plans for under-performing tasks.

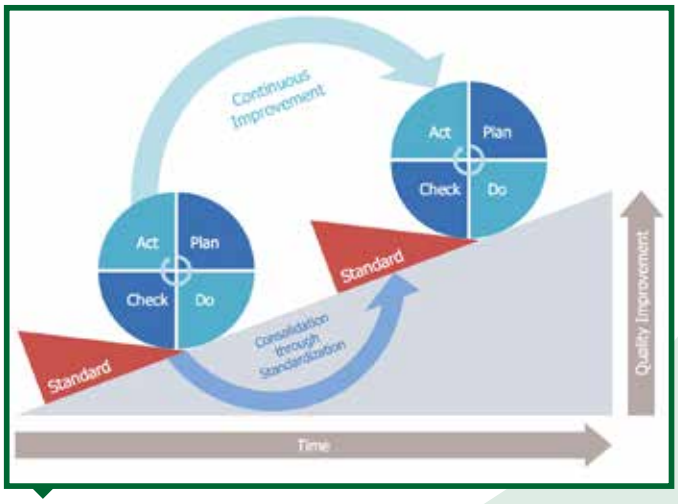

Figure 2. PDCA Cycle

One of the key components of this PDCA cycle is the Check step wherein a quantitative risk analysis is carried out on those items that present themselves as potential impacts to the project baseline. The evaluation of both the likelihood and impact of such an event acts as an early warning system and also gives our project managers greater confidence in their decisions on what mitigation action is required. This weekly cycle drives focus on the schedule and provides the prompts for our project managers to keep their fingers on the pulse regarding project performance. Fundamentally, the steady improvement in the quality of project planning increases as the project grows through each phase.

Lean Initiative Improvements & Impact

RAID implementation

The benefits that RAID analysis brought to our master planning were immediate and brought more certainty to the schedule through the assignment of action plans to the various stakeholders. The incorporation of the RAID log to the weekly pull planning sessions on our South Dublin project was therefore a natural step forward on our Lean journey. During these weekly pull planning sessions (Figure 3), the project manager is now mandated to update the log and track all risks, assumptions, issues, and dependencies in a transparent manner as the various subcontractors step through their look-ahead tasks for the following period.

This collaborative approach to planning also lends itself to increased workflow efficiency at the package interfaces and promotes a safer working environment for our subcontractors through the clear understanding of 'make ready needs'.

The coordinated and timely management of the project constraints makes it a lot easier for our project management team to identify potential bottlenecks well in advance, triggering the need to devise an appropriate path to risk mitigation. On this particular project, this weekly engagement of RAID analysis resulted in a 2-week improvement on a 16-week target duration for the completion of the RC structure. By focusing on the RAID components, the project team was able to move roadblocks in a timely manner, and ultimately drive efficiencies within the formwork workflows, increase productivity and improve this critical path activity by 12%. The efficiency of our procurement has also vastly improved thanks to the early and appropriate categorisation of project constraints during these sessions.

The integration of the RAID log provides the platform to focus on long lead items – revisiting these inputs every week prompts the project team and subcontractors to address typical issue such as open RFIs/submittals that could potentially delay material orders for example. Long lead elements relating to the curtain walling package on this project were able to be procured on time as a result of this weekly focus on constraint removal through RAID. Moreover, the logging of constraints has led to increased morale throughout the supply chain as all LLP participants now know that their voices will be heard and concerns recorded through the RAID log.

Figure 3. Weekly Last Planner Session

Project Controls-PDCA cycle

The recent enhancements that we have made to our Project Controls tools have now been introduced across all Collen projects, both in Ireland and Europe. The cyclic nature of our embedded PDCA model promotes a ubiquitous approach to project planning, providing the tools for our project managers to de-risk areas of concern associated with the project schedule. Not only does this form of risk management provide a roadmap for improved schedule adherence, it establishes transparent and real-time data on on project performance for all stakeholders.

By adopting a standardised approach, we can ensure that the project KPIs are communicated in a consistent and concise manner. This enhanced form of schedule planning has also vastly improved the execution of project planning at project management level, with a notable improvement on project SPI values along with minimal variance to the key project milestones across a number of projects. In fact, we have witnessed an improvement on schedule performance across 80% of our projects over the last 6-month period, with the critical milestones coming in on or ahead of schedule. Our project managers' ability to manage schedule risk has been bolstered with the addition of this new technique to their toolkit for successful project management.

Company Overview | Modubuild | modubuild.net

Formed in 2006, Modubuild specialises in the delivery of internal modular fitout and high-tech, turnkey, modular off-site buildings. With significant year-on-year growth, the company has focused its business model towards high-tech manufacturing, biopharma, pharmaceutical, and data centres. Headquartered from Kilkenny, the company operates on an international basis with offices in Manchester, Brussels, Amsterdam, and Helsinki.

Lean thinking is part of the DNA at Modubuild and has been central to the company's growth and success. Operations are not framed within the business as Lean, but more as an unconscious part of daily activities within a learning enterprise.

With Lean thinking central to the company's operations, Modubuild has constantly evolved and applied CI and VSM to its operations. Across the business, Modubuild strive for Operational Excellence (OpEx), using Kaizen and CI as a key business focus. The company's approach is that everything must add value and operations and processes can always be improved. Data is collected across all business departments and collated to develop thematic trends and provide pertinent data towards how operations function. This data can then be developed to provide clients with the most efficient, professional, and comprehensive service possible.

Figure 1. Modubuild Off-Site Fabrication Facility

Authors

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Overview & Background to the Lean Initiative

In September 2019, Modubuild was approached by this case study's client – a large international biopharma company – that is developing a multi-phase manufacturing facility and it challenged Modubuild to develop and deliver a turnkey fast-track 900m2 BSL3 twin-storey laboratory for the propagation of cell cultures used in the manufacturing of vaccines.

Setting a complex and challenging set of parameters and deliverables, the client required the project to be designed, procured, and constructed in a 20-week period.

During this 20-week period, Modubuild was required to deliver a complete turnkey building, including CSA and MEP packages, fitted furniture, finishes, FAT, transport to site, and module installation.

By applying Lean strategy to this project, Modubuild used its extensive modular experience and learnings to harness a hybrid construction approach of traditional stick-build methods and incorporated those into a modular volumetric off-site concept and design. By providing a structural steel frame, flexible concrete floor screeds, architectural cladding and roofing, coupled with internal CSA package and a complex MEP scope, Modubuild delivered this complex project to 92% completeness within the 20-week period.

Figure 2. Module Loading at the Modubuild Off-Site Fabrication Facility

Lean Initiative Undertaken – Lean Thinking, Tools, Techniques

Taking an OpEx approach, Modubuild adopted various Lean tools and techniques to deliver this off-site project. Though the project was being constructed using traditional construction methods and sequencing, its success in delivery was based on contemporary Lean strategy. Reduction and elimination of all 8 Wastes was prevalent throughout. Resources were allocated and directed based on demand, thus ensuring each person involved was adding value and increasing input and guaranteeing that output was managed and optimised against the project schedule. End-to-end collaboration succeeded in the endeavours to eliminate waste and maximise value-add, thus delivering a challenging and complex volumetric project at rapid speed. Furthermore, the Lean approach ensured that the client was provided with a finished building with zero defects.

Standardisation in design and module assembly allowed for a linear manufacturing process. A Lean production line was used for fabrication of modules. Steel fabrication occurred first, followed by painting, then floor insulation and concrete screeds. Following completion of these stages, modules were moved to ito the building assembly zone of the factory where units were connected, and MEP and internal finishes installation took place. By taking intrinsic control of the extrinsic factors, Modubuild could sequence works to ensure weather conditions did not affect progress, therefore external cladding and roofing were some of the final packages to be fitted. Success in rapidly completing these steps in a phased and linear method formed the foundation for successful off-site completion.

Without having to wait for completion of groundworks, concrete pours, and slab curing, the project proceeded in the controlled factory environment. To ensure consistency, each stage of the fabrication line went through digital BIM 360 field quality assurance checks. By creating a Lean standardised manufacturing environment, Modubuild achieved many meaningful and tangible wins on the project, most notably right first time, and achieving zero defects or EHS breaches at project completion – all of which contributed to Modubuild succeeding in delivering the project within the 20-week period. By accurately sequencing all works and applying LPS, Modubuild optimised the value chain and created pull throughout the project, thus allowing it to effectively and successfully practice JIT and prudent inventory management on the project.

Throughout the project life cycle, Modubuild's team strived for excellence in planning and work execution, but most importantly demanded and delivered exceptional quality standards. The first and most critical task for Modubuild was to appoint a collaborative team of specialists and trade partners. Working in an efficient manner, Modubuild appointed a value stream including Jones Engineering as MEP trade partner, Asgard Cleanroom Solutions as cleanroom provider, and McElroy & Associates as engineering design consultancy and BCAR specialists.

To ensure efficient collaboration and effective communication across the value stream, both client representatives and the conglomerate of trade partners were based at Modubuild's 145,000 sq-ft off-site construction facility located on a 15-acre site in Castlecomer, County Kilkenny. This ensured that key decision-makers were present at the requisite gemba, thus allowing for complex issues that could have affected project delivery to be dealt with and closed-out without detriment to the overall schedule. A key fundamental for the team was to adopt the 3C approach: Collaborate, Confirm, Construct. Having the key stakeholders present at the gemba enabled efficient and effective execution of the 3Cs. Throughout the life cycle of the project, all stakeholders were committed to the philosophy and thus enabling waste reduction in terms of time and rework. This created a speedy level of responsiveness from client representatives and the Modubuild design team and trade partners.

By using the 3C strategy, Modubuild and its trade partners achieved significant waste reduction across various waste categories. For instance, having the key decision-makers present at the place of construction enabled efficient and decisive decision-making which resulted in the removal of waiting. Within construction generally, waiting for key decisions is a common waste and cause of frustration for construction teams and it can negatively impact project timelines and schedule. In turn, this enabled project operations and fabrication to progress efficiently in line with the LPS and project schedule. Subsequently, the removal of time-associated waste enabled the construction programme to progress as planned.

Figure 3. On-Site Module Installation, & Assembled Building

Accurate end-to-end project planning was a critical element in project delivery. Modubuild used a 20-week LPS system to manage and plan all off-site activities across the various packages and trade partner elements. The LPS board was erected in the project office in clear view of all personnel. It was updated weekly, or more frequently if needed, with

valued input from the respective trade partners to ensure all milestones were achieved and look-ahead was accurately planned. From the LPS, a detailed schedule of design, procurement, and construction deliverables were developed. This ensured technical submittals were approved quickly and efficiently – to optimise decision-making, the client always returned tech sub-approvals within 48-hours or less – that design was completed, and materials procured on a JIT basis.

The accuracy of the LPS enabled the procurement team to develop a tiered procurement schedule. With critical client input, procurement tiers were categorised based on lead time, critical importance to the project, and priority of requirements. For instance, cladding and roofing were long lead elements, with a 15-week lead time. In traditional on-site construction, this would have been detrimental to project delivery. However, by constructing off-site within a controlled environment, Modubuild could progress with all the internal packages on the project, thus ensuring that the 20-week schedule was optimised and progressed on a daily basis.

By accurately scheduling procurement deliverables and using JIT, the team successfully reduced more common wastes, including excess inventory, transportation, and motion/material handling. The frontend planning and LPS process allowed the project team to slow down to speed up. Furthermore, by critically planning and prioritising product selection, design, and procurement, it allowed all stakeholders across the value chain to focus and prioritise their energies to the elements that were most important. Furthermore, it empowered key decision-makers to rapidly find effective solutions and progress complex issues.

BIM Modelling and effective design management and execution were key factors in the successful delivery of this off-site 3D volumetric modular project. From the point of order through to project delivery, the entire design team, specialist trade partners, and the client were based at the single design office within Modubuild's factory. This allowed for detailed and efficient collaboration throughout the lifecycle of the project, thus ensuring efficiency and tangible milestones were achieved throughout. Additionally, it ensured elements were designed at the place of construction, thus enabling a high level of right first time and further reducing wastes such as reworks and over-processing which enabling expedited completion of design and BIM completion.

The evidence certainly suggests that collaboration had a significant and positive impact on the project – the importance of which cannot be overstated. Throughout, the client challenged Modubuild to deliver and respond with effective and SMART problem solving. This challenge empowered Modubuild and its team to be proactive and have solutions ready. By challenging Modubuild, the client forced the value stream into an efficient and highly-effective cycle of receiving questions, answering questions, and receiving approval. Essentially, challenging the value stream and its key stakeholders enabled a collaborative and integrated delivery of the project. Modubuild was very clear at the outset of the project that all submittals had to be reviewed by the client within 48 hours in order for the schedule to be maintained. This proved to be very successful as it greatly increased the efficiency of the procurement process in comparison to traditional build projects.

Figure 4. Module Internal Finishes – completed off-site

From an end-user perspective, exceptionally sensitive and critical activities and operations would occur in the completed modular building. The primary function of a BSL3 laboratory building is for the propagation of life-saving vaccines against dangerous and highly infectious diseases and viruses. This meant that it was essential that quality of build and system installation were to exceptional quality levels – any breach or defect could potentially lead to catastrophic outcomes for the client and its employees. Furthermore, selection of building elements and components needed to be onerous but efficient, and not negatively impact the 20-week project schedule.

The project schedule could not afford delay through reworks due to delayed approval of systems, or benchmarks, or quality of installation. As mentioned previously, the construction team operated proactively using the 3Cs which enabled efficient decision-making and progress. It was also important that the quality of construction met client requirements and was right first time, and so it was prudent that all elements were benchmarked and approved, and consistency was achieved. Therefore, the team and installation operatives strived for excellence. Having the client present at the gemba resulted in quality at source, therefore expediting construction to unparalleled speeds whilst achieving best-in-class quality across all elements of the project.

As a facility-ready, plug-and-play, off-site constructed building that contained various and intricate electrical, HVAC, process, security, active fire protection, and BMS systems, it was essential that exceptional quality testing was completed. Modubuild and its team designed the project to ensure that all these systems were entirely installed in the off-site environment. This subsequently required that Factory Acceptance Testing (FAT) be completed on all systems within the 20-week off-site construction programme, subsequently shortening the allowed installation time. Taking the construction and installation into the controlled off-site environment ensured right first time, reduced reworks, and allowed for pre-FATs to be completed sequentially and successfully – thus for final FATs to pass on the first effort each time. Finally, upon completion of all off-site works, the entire modular building was powered-up and put into fully operational mode. This allowed the client and others to carry out actual walk-throughs of the complete facility and assess any alterations or comment on any final quality topics prior

any alterations or comment on any final quality topics prior to site delivery. Importantly, this stage provided the client with certainty and comfort that the building operated to fully meet their deliverables and expectations.

With design and construction having commenced in September 2019, the completed building was in position and ready for module delivery from Modubuild's off-site facility in Kilkenny during the first week of February 2020. The separation and weather wrapping of individual modules coincided with the commencement of groundworks at the final building location on site. Just five months after placing its order with Modubuild, the client received delivery of 18 11m long x 4.5m wide x 4.5m high mega-modules.

The transport of the mega-modules was coordinated with oversized load experts, Aylward Haulage, and relevant local authorities and councils. The first mega-modules arrived on site on 14 February 2020, and, following 9 days of module installation, a two-storey weather-tight building was fully in situ. This was the point where extrinsic factors affected progress as severe weather conditions impacted installation progress – without having encountered two significant storms, installation would have been achieved in just 5 days.

Onsite activities continued, including reconnecting and commissioning of electrical, HVAC, process, owner-furnished and contractor-installed equipment. The building consisted of 65 CSA and MEP systems. There were a number of these systems commissioned during a short period and as they became available. The remaining systems were completed over an expedited period after returning to site following the Covid-19 restrictions. Critically for the client, they were considered to be essential workers. As the laboratory was facility-ready with systems operational and owner equipment in place, end-user staff could move into the building to commence placebo operations within the building during the Covid-19 lockdown.

Lean Initiative Improvements & Impact

For the client, the BSL3 laboratory is considered to be a mission-critical element of infrastructure essential for successful manufacturing of life-saving drug vaccines within its main production facility. Without a functional and high-quality BSL3 laboratory, the manufacturing processes could not commence. Failure or delayed delivery would have resulted in serious impact on the functions of the client organisation. For these reasons, it was of critical importance that the completed building was constructed and delivered in a fully scalable, replicable, facility-ready, plug-and-play condition within the 20-week time parameter.

By approaching this fast-track and complex project with volumetric off-site construction, and by applying contemporary Lean thinking, Modubuild delivered, and in many cases exceeded, client expectations, deliverables, and requirements. From concept design through to project completion, the key focus was to optimise, manage, efficiently plan, coordinate, and execute all intrinsic elements. Through developing an accurate LPS, Modubuild created its basis for successful completion of the intrinsic elements of scope, including design, procurement, off-site construction, module delivery, and site installation.

Waste removal and addition of value was a key priority. By ensuring detailed and efficient collaboration across the entire value stream, the project team created an environment for swift and effective decision-making. Importantly, resources were accurately planned and this ensured that all personnel were always adding value. Interestingly, through planning resources and workload, data shows that the project was completed with approximately 45% less personnel than would have been otherwise required on a traditional on-site build equivalent.

Figure 5. Plant Room & FAT Testing Station completed off-site

Success in delivery of quality was a significant achievement on the project. All punch-list items were closed-out at the off-site facility prior to delivery. This ensured that the client received a completed facility-ready building and did not need to wait for extended periods for close-out of any snags or punch-list items. Following installation of modules and connection of systems, the building was ready with zero defects reported. This copper fastened Modubuild's pre-requisite of waste elimination. Using Lean thinking and practices to provide a completed volumetric modular off-site building on time and with zero defects allowed the client to move into operations approximately 12 months earlier than would have been possible through traditional construction. Essentially, this empowered the client to produce its life-saving vaccines 1-year earlier than planned – the ultimate definition of value-add for such a client.

MODUBUILD

Company Overview | Mercury | mercuryeng.com

MERCURY
YOUR VISION, OUR DUTY.

Mercury is a European contractor that builds and manages complex engineering projects that reimagine how people work and live in the built environment. Mercury believe that real innovation happens if you are willing to be brave. Its determination and sharp focus enable Mercury to deliver leading-edge construction solutions across a range of key sectors, taking our clients to new territories they never thought possible.

Mercury's purpose is to deliver its clients' vision through leading-edge construction solutions, going beyond their duty which turns clients into partners and builds relationships that thrive across the following sectors: Enterprise Data Centres; Hyperscale Data Centres; Life Sciences & Technology; Building Services; Healthcare; Fire Protection; and TSS.

Author

Antoin Earle

Overview & Background to Lean Initiative

Over a 48-year period, Mercury has built a reputation for delivering complex engineering projects across a range of key sectors. This case study focuses on historical initiatives undertaken for a large-scale semi-conductor client where Mercury has been at the forefront of new and retrofit project build activities since it was a green-field site in 1992.

In terms of capital project timescales, clients' needs dominate our focus on how we plan for and execute any project build in the context of safety, cost, quality, and time. Fast-track scheduling, in particular, brings enormous challenges for procurement teams in meeting client expectations due to the risks inherently associated with the unknown. Long lead-time materials procurement on a global scale requires, of course, a clear understanding of the product, but also of the relative weight and fluidity of the tiered conditions in the supply chain.

These conditions ultimately determine the extent to which materials can be procured efficiently and to which relative wasteful activities can be reduced or completely eliminated.

When taking into consideration that over 90% (by value) of spend on materials for this sector is bespoke, the challenges grow exponentially as the project footprint and complexities increase and the relative project timelines decrease. During the ten years from 2010 to 2020, we have experienced additional compression of up to 20% on standard project timelines. Along with this, we have encountered increased risk of time-based contractual penalties being imposed. Growing costs associated with expediting materials which have been placed on order either too late to the schedule or not placed at all, begin to impact contractors' ability to meet their own budgets and inevitably have the potential to impact the construction schedule overall.

Lean Initiative Undertaken – Lean Thinking, Tools, Techniques

This case examines Mercury's eight-year Lean initiative to make its procurement systems and processes more effective and more efficient, with the focused aim to return substantially enhanced value-add to its client. During completion of a project in 2011 and commencement of a new project build in late-2012, it was recognised that there were significant process gaps in the end-to-end materials procurement function. Traditionally, construction teams lead the procurement process and this is due to legacy factors like, for example, the traditional view of procurement as an administration function and the lack of professional procurement representation at senior level. Procurement teams typically focused their attention on placing purchase orders (POs) as quickly as they could, and spent much time reacting to the lateness and or inadequate nature of requirements coming downstream. Achieving the "best price" essentially entailed the leveraging of personal

relationships and rarely involved standard industry practice in terms of bid analysis (BAS) methods and objective negotiating techniques.

By now the traditional approach of having one primary "issue for construction" (IFC) design package and a schedule that was based on all systems being completed prior to handover, had been replaced with multiple IFC design releases and systems being completed for handover progressively throughout the project. This led to systems being handover while the majority of the project was still in construction. This necessitated a sea change in how "material take off" (MTO) was being completed and material procured. It is fair to say that this change was still being implemented and consequences understood at the initial stages of the project which led to traditional bulk MTO being completed and which did not necessarily accommodate the early systems material requirements. Obviously the partial IFC design release also necessitated placing orders for long lead material prior to "issue for fabrication" (IFF) being achieved. In summary, large volumes of material were ordered, but to ensure the correct material was ordered in time, a change in the process was needed and quickly.

The initial fix was to create an Excel spreadsheet that would capture all MTOs as they were being completed for each part of each system on the project and in line with design release. The engineering function designed this template for use by the engineering and construction teams. That spreadsheet became known as the "engineering materials report (EMR)". This served as a tracker to ensure MTOs were being done and to also ensure that orders were being placed on time against each MTO. Estimated lead-times were factored in for critical materials, and PO required dates were calculated on field-need-date (FND) less the estimated lead time. This model served us very well, and still does so to this day with many tweaks and small improvements since. Within six months of its introduction, the project team was satisfied that all materials that should have been ordered were ordered. This brought materials ordering up to date and the next challenge was to design, implement, and maintain an ongoing and efficient set of processes that would ensure consistency and standardisation in the long-term.

The procurement "RFx" encompassed the entire formal request process and included "request for quote" (RFQ), "request for information" (RFI), and "request for proposal" (RFP). Into the RFx process itself consisted of numerous methods – none of which were contained in an SOP and all of which were subjective in terms of market engagement. A root cause analysis (RCA) identified that a person with experience would approach the vendor market in a completely different manner to a junior with little or no experience. There was literally no control over who should and should not approach the market place, nor how they should do so. Decision-making was uncontrolled to the extent that vendors could receive verbal instructions to any value. These methods manifested in a lot of wasted time for engineering, construction, procurement, and finance.

Ultimately, procurement people who were tasked with ensuring suppliers received their POs and that materials arrived on time, were faced with a relentless flow of last minute requests. This resulted in large volumes of POs being issued to market on the basis of quotations received by numerous people outside of the procurement department. Analysis found that up to 40 people were involved in the RFx process, including four buyers. Furthermore, due to the late nature of POs, the supply chain itself was formed out of discrete knowledge that vendors had about the project and around specific relationships forged as a result. Ultimately, the procurement function was at the mercy of its supply chain and could only rely to a large extent on those personal relationships to achieve any level of satisfaction that project timelines could be met. There was a very clear need for a strategic, objective, operationally excellent, and consistently applied standard work approach to procurement.

Utilising Pareto analysis on spend, we categorised at a high level not only where the spend was going but how much effort was associated with each category. It was notable that 80% of total PO spend was awarded to 10% of the total vendor base, with one vendor accounting for 17% of spend, and 312 vendors accounting for the remaining 83%.

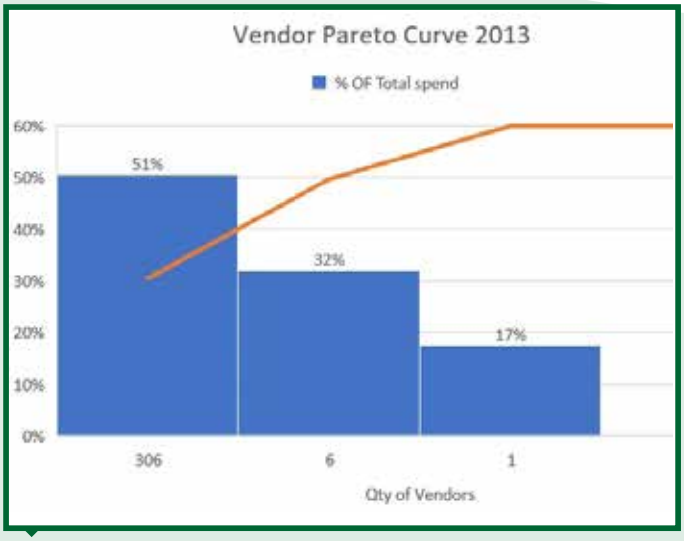

Figure 1. Vendor Pareto Analysis

A further drill-down of the top seven vendors (totalling 49% of spend) to examine why and how spend was allocated, found the following:

- Procurement was not involved in most of the big decisions and were not involved in the initial product submittal and approval phase. Client approval takes time, and Procurement needs to be involved at the earliest stage to provide alternatives for submittal.

- Quotations from suppliers went to people outside of Procurement and were only provided to Procurement when the material was being requisitioned for purchase. This left zero time to adequately go to market for alternative bids.
- Most quotations contained either a sea freight or an air freight adder, and which was approved by someone outside of Procurement. Airfreight alone accounted for 2.25% of total project spend.
- Strong relationships were built with the suppliers and it was hard for people to change from the practices and people that they were used to.
- Some suppliers provided on-site assistance to junior engineers with MTOs, which therefore reduced competition.
- There wasn't enough information available to enable proactive procurement.
- Requisitions mostly contained free text which gave very little detail about the product being requested. POs were processed based on quotations provided by people from outside of Procurement.
- In the case of one supplier, most of the products ordered could have been purchased from official distributors locally.

The most significant finding out of this RCA was that, given the repetitive nature of the equipment, we had no agreed materials list and no agreed pricing structure with vendors. Data capture in our ERP system was not being maximised to enable an efficient and standardised approach to purchasing regularly bought items.

We deployed the DMAIC method to set out our plan in terms of understanding more about the issues and solving them. The objective was to improve the buying process to a point where all repetitive materials could be bought quickly, competitively, and to the correct specification. The focus moved to having the right information, and to having it early and consistently. The need for having robust and standardised information, readily available to key users, formed the basis of thinking over the ensuing years. In fact, it became mostly about how to manage the information and capture the critical data.

Defining the problem

Taking into consideration the findings of our initial review of vendor spend, the extended analysis of high value suppliers found that:

- Where procurement had an opportunity of increased early involvement, data was not being captured in the ERP system that would empower the team to be more proactive in the RFx process. The symptom in this instance was that POs were being placed with the same suppliers based on historical purchases.
- In scenarios where RFQs were being issued to market by procurement, they were being repetitively issued for the same products.
- RFQs were being issued post-requisition approval in all cases, and there was zero long-form RFQ for bulk price leveraging.
- The procurement function was consumed with processing POs, with little or no time available to agree long-term conditions with vendors or to think and act strategically.
- 100% of RFQs issued were in short-form outputted from the ERP. Short-form RFQ from the ERP does not ensure all terms and conditions (T&Cs) are captured in the tender process and only focusses on the price of a material.
- Much wasted time was subsequently spent processing invoices. Lack of accurate information and verbal instruction were the main root causes for misaligned invoices.

Measuring and analysing the issues

Our first task was to examine the data available in the ERP system and understand the reasons why this data was not being used in the initial phases of procurement. The main findings were that:

- Most of the data on the ERP system was either out of date or inaccurate.
- Engineers and construction people spent too much time searching for information on the ERP and they could not rely on it because it was not clear.
- It took too long to get new material data set up on the system.
- The people responsible for raising requisitions were not adequately trained to do so.
- On further analysis it was shown that the procurement team spent up to 50% of their time resolving queries that were raised by vendors due to the inadequate information provided on RFQs.

Each material data record in the ERP is known as a "material master" (MM). In mid-2013, there were approximately 30,000 MM records in the ERP, and findings included:

- Only 2,500 records could be used with a level of accuracy that would enable a piece of equipment or material to be purchased using that data alone.
- Only 45% of POs contained MM.
- Of the 2,500 MM that could be used, for every PO that was raised, a short-form RFQ was also raised.
- Zero agreed prices locked into our ERP system.
- Approximately 50% of RFQs were being issued to the market repetitively for the same material.

Improving the situation

Our objectives started to form organically as we worked through analysing the problems. At a high level, these objectives were to:

- Create time for experienced procurement people to work strategically by removing constraints such as administrative buying.
- Build a data library that was robust enough to encourage engineering and construction to use it in the early phases of planning and material requisition.
- Forge relationships internally that would assist in making things happen.
- Forge relationships with key vendors who would see the benefits of standardising how we interacted with them.
- Create SOPs and train users to be experts in the new processes.

Lean thinking was born in manufacturing out of the need to make things better and to be more efficient. We began looking at ways to leverage learning in how manufacturing procures raw materials. In manufacturing, production planning requires forensic detail on materials availability, cost, and specification. Each material and component is identified with a unique identifier specific to that material or component and specific to each vendor it is procured from. On review of the data in our own ERP, very few of the 2,500 active MMs contained detailed product descriptions to include, for example, client specs, manufacturer part numbers, lead times, units of measure, or pricing. Most of the MMs were generic and required further manipulation/editing, either as part of a requisition or PO. This more or less rendered the MMs in the system useless as the various editing of the same MM would ultimately change the conditions in our ERP and, consequently, automation and meaningful analysis were impossible. We needed to take a common-sense approach given the volume of variables in materials conditions and the bandwidth of the supply chain.

The task was to have manufacturing grade data for all materials and equipment to be procured, and specific to each vendor. Key data required included: item descriptions; client specification; supplier and/or manufacturer part numbers; units of measure; agreed prices; and agreed accurate lead times.

The data build was broken into three key phases, commencing in 2013. At the time of writing, ongoing updating and maintenance of the data is simply "how we do things around here"; however, to suggest in 2013 that this would be the way we would do things for all materials would have been a big and bold statement. Tasks and activities contained in each element were not limited to just those set out in each element as, in some cases, all elements of work for some vendors were achieved in the first two years of the initiative. As client project work ramped down in late-2014/early-2015, the Lean initiative's work also ramped down. Into 2018/2019, and in preparation for the 2020 project build for the same client, this Lean initiative recommenced.

Element I – Commenced 2013

The focus here was primarily on cleansing the existing data in the system and agreeing a process to set up new data that would suit the construction team, the engineering team, plus the vendors. Key activities carried out during this phase included: initial data cleansing of obsolete records in the ERP system; developing an ongoing obsolescence procedure; implementing a process of ongoing communication with vendors for all new data set-up to ensure continuous alignment of supplier and manufacturer part numbers; commencing realignment of supplier quoted units of measure (UOM) against our MTO UOM; and commencing an agreed pricing model for 2,000 individual materials.

Element II – Commenced 2018

The focus here was to agree pricing T&Cs with suppliers. The main challenges with this phase was to agree long-term and medium-term pricing with suppliers. In particular with commodities that are high-value bespoke items, the supplier reluctance to commit became our biggest challenge.

Processes were agreed where products were categorised and expiry dates on prices were integrated into the ERP system. We set up price information records (PIR) with key vendors. We enabled access to commercial teams to view PIRs for budgeting purposes, and we set up an agreed BAS process. We collaborated with the BIM and Engineering teams to ensure that new data set-up was cleansed and approved through the design specifications. Even where long-term pricing could not be agreed, the work associated with the initial phase enabled a much more efficient turnaround of "price on application" (POA) queries.

The extra time saved enabled several outcomes, including: semi-automated PO process; set-up of consignment stock agreements; better competition in the market due to increased time to conduct RFQ and BAS; increased focus on managing stock at hand; increased number of progress meetings with suppliers; increased time for reporting to senior management; better quality reporting to senior management.

The most significant shift in activity with this phase was the reduction in reliance on discrete knowledge. Regularly bought items could be processed by junior team members and work could be seamlessly reassigned to others less experienced. Time was created for more strategic tasks to be executed by the more experienced team members. Point in case was that a new buyer to the company with no experience in the industry did most of the day-to-day buying for a smaller but significant project in 2017 for the same client.

Element III – Continuing in 2018

The focus here was to agree lead times. For project planning to be effective in the context of materials scheduling, it is necessary to know the relevant lead times, the long lead, the local supply, and where risk lies. On any project, experienced people will easily call out some of the historically long lead items, but this is not an exact science in itself. The basis of the EMR referred to earlier, is that POs are placed based on a need date in the future – the FND. Required PO dates are calculated very simply by ordering on or before the FND, less the lead time, and allowing for a buffer time. The logic of the buffer time is to cover where delays might occur and/or to allow for procurement RFQ timing.

FND=**X** – Lead Time=**Y** – Buffer time=**R**
– Required PO Date=**Z**
Z = X-(Y+R)

This formula is the basis for the timing of cutting POs; however, it is laden with risk due to the fluid nature of material availability. Factors such as quantity, required date, budget, client specification, minimum order quantities, delivery methods, and customs considerations, all weigh heavily on the validity of lead times quoted, and accuracy and honesty also play a big part. Suppliers had a huge

part to play in this phase. Some risked overcommitting with aggressive lead times that they could never meet just to look favourable at tender stage. Others did the opposite and quoted extended lead times which put them at risk of losing potential business. Order too late and the schedule is bust – Order too early and you impact cash flow at the very least.

The main tasks carried out during this phase included:

- Analysing all historical data pertaining to actual delivery times.
- Extending data library to include all size ranges, specifically out of gauge outside diameters.
- Categorising materials as "critical" and "non-critical".
- Engaging with key vendors to establish best and worst case scenarios for material lead times.
- Validating vendor data against historical data where possible.
- Validating data for new materials through open discussions with vendors and manufacturers.
- Comparing lead time data between competitors.
- Agreeing and inputting lead times specific to each material and each vendor.

Element IV – December 2018

The focus here was on aligning planning with execution vis-à-vis materials management. In preparation for the next major project with this client, new challenges were presented in terms of materials management. The scale of this project (in construction phase at time of writing) is much greater than anything we had undertaken before. Added to that, the project would be built using the "advanced work packaging" (AWP) methodology which is a structured approach to improving construction projects from design to commissioning, and is accomplished by aligning planning and execution activities throughout the project life cycle. It is such rigourous front-end planning along with the detailed engineering activities that support enhanced execution at the workface, and, in construction, the workface is where trades turn materials into functioning plant. Project set-up and planning establishes the basis for coordinated "construction work packages" (CWPs) which are strategic subdivisions of the "construction work area" (CWA). A CWA is a section of the construction site that has been defined as a logical area of work. CWPs then enable progression of work by the planning, execution and monitoring of more granulated "installation work packages" (IWPs).

The need arose to carry out a full review of our materials management processes to identify areas of risk in terms of how to plan for and execute the end-to-end materials management function. In December 2018, we engaged an external Lean service provider to carry out a full Lean review of our systems and processes, and to make recommendations for improvement. The brief was to evaluate the materials management process (which does not add specific value but supports value creation); conduct a current and future state analysis; and make recommendations on how we could achieve the future state. The primary recommendations made were to improve the functionality of the then Excel-based EMR process, and to give consideration to long-term ERP materials planning and migration from Excel-based planning to fully integrated MRP.

The following were undertaken as part of this element:

- Interviews with all key stakeholders.
- Value stream mapping (VSM) on our Order & Receipt process for stocked materials.
- A Kaizen event to highlight wastes.
- A workshop to identify and prioritise Kaizen tasks.

Figure 2. Value Stream Mapping

Lean Initiative Improvements & Impact

We faced many challenges on this Lean initiative. Operationally, we had to get people to help and keep up the effort as well as to create time to work on enormous volumes of data. With the Supply Chain, we had to get suppliers on-boarded, and we had to keep them interested when there was no immediate benefit to them. Culturally, within both the Procurement function as well as across the wider group, we had to enable the changing of long-held practices and attitudes by introducing the Lean mindset and tools to Procurement. The overriding challenge was encapsulated in the statement that "This isn't for us, this is all about manufacturing. What has it got to do with Procurement?"

There have been a number of high-level functional impacts, including:

- During our last major project with this client we had 2,500 partially useful MM in our ERP system. At the time of writing, we have 53,000 PIR agreements (Item, Lead time, and various Pricing T&Cs) across 112 vendors. Improvements to these numbers is now seen as "how we do things around here".
- When we commenced these initiatives, we did not have a long-form RFQ process in place. We currently issue all major packages to market via long-form RFQ. This process ensures we request and capture all pertinent information regarding pricing and T&Cs.
- Increases in efficiency on admin buying has created value-add in terms of enhanced strategic skillsets to the procurement function. Compliance and governance play

a huge role in our daily operations, and, in 2013, we did not know exactly how compliant we were but now we have the systems, data, and people to measure it and to manage it.

- End-to-end supply chain management of key categories, Lean supply chain, and full end-to-end logistics control from manufacturer to site. On previous projects, some of these categories were de-risked through the use of distributors.
- Spend is now apportioned more objectively across the supply chain with key partners, both in terms of consolidation and spread. Risk has been reduced significantly as there are more competitors and alternatives in the market place who are willing and able to meet our requirements.
- We have a full suite of procurement reporting on BI including:
    - Materials expediting
    - Schedule impact mitigation
    - Inventory management
    - Vendor performance
    - Price
    - Lead times
    - Quality
    - Purchase Price Variance (PPV) management
    - Budget management
    - Transport costs
    - Incoming freight
    - Internal transfers
    - AP management
- On-site JIT vendor managed inventory (VMI) agreements with four key vendors. These agreements mean that key consumable type materials, which were traditionally purchased on a daily basis, are now on site and managed by the vendors. Key vendors have invested in and implemented on-site scanning systems that enable Mercury personnel to collect materials on JIT basis. Downtime associated with waiting for materials to arrive to site is essentially eliminated for these categories. Daily POs to these vendors is limited to one PO per month.
- The use of standardised material data has improved from 45% in 2013 to 99% in 2020.

There have been benefits in terms of buying activity, including:

- Continuous flow – Zero lag time from requisition to PO for 53,000 SKUs – Takt time reduced.
- Increased time to focus on critical high value procurement activity – Opportunity time increased.
- Consistent pricing agreements.
- Average PO value in 2020 is five time greater than in 2013.
- 43% decrease in the number of POs per buyer.
- No increase in the number of buyers on a project that is four times larger and more complex than the previous major project undertaken.
- 95% decrease in the number of engineers processing requisitions.

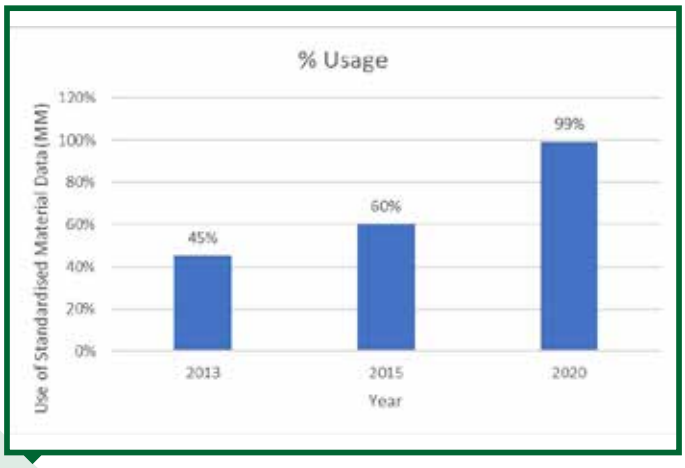

Figure 3. Usage of Standardised Material Data

Supplier agreement improvements include:

- In 2020, there are 112 supplier agreements in place (in 2012 there were zero and 2013 there were four).
- In 2020, there are 53,000 PIRs in place (in 2012 there were 2,500 MMs in place – prices only).
- In 2020, there are four Consignment stock agreements in place (in 2013 there was one Consignment stock agreement).
- In 2020, Procurement is driven by Procurement, with SOPs in place, whereas in 2012 Procurement was driven by construction with a high-risk SCM strategy.

Figure 4. Migration of Spend from Key Distributor to Manufacturer

In terms of alignment of spend, Figure 4 illustrates an example of one key vendor where 2020 spend is limited to sole source equipment only.

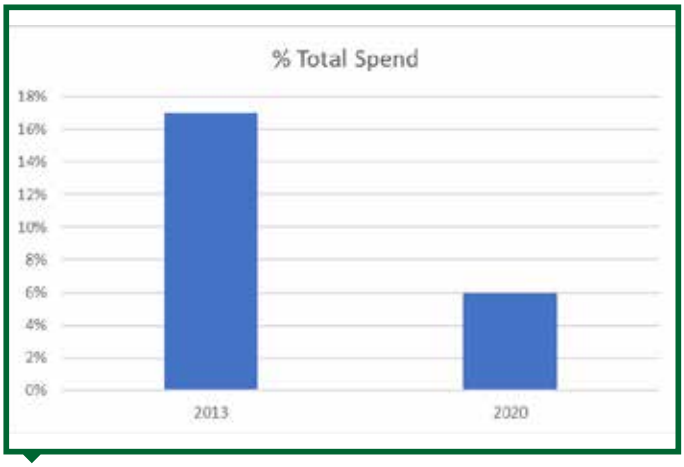

Figure 5. Lean Supply Chain Example

Born out of a need to do things better for our client, this Lean initiative has been an enormous and long-term undertaking to enable full implementation of material master usage on SAP and entailing large-scale information management. Lacking formal training in Lean within the Procurement function until 2015, this project hit many speed bumps throughout its eight-year period; however, two critical factors stand out as being pivotal in achieving the initial objectives set out, namely the team approach and the commitment of Mercury senior leadership in making it happen.

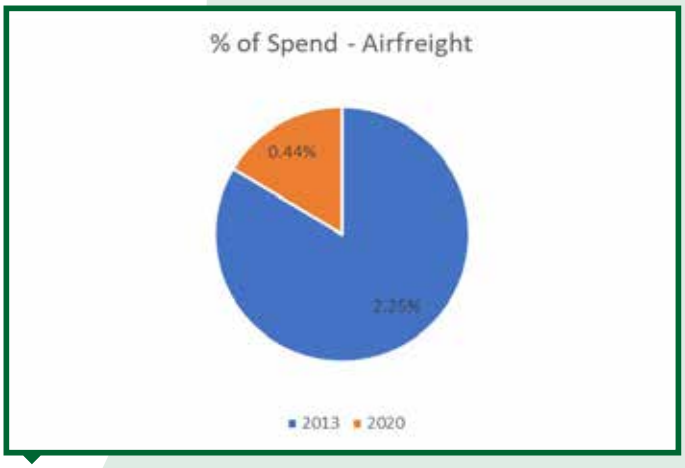

Figure 6. Reduction of Costs Associated with Purchasing Late to the FND

We now have a fully integrated EMR on SAP ERP, coupled with a Materials Requirement Planning (MRP) materials demand planning system going live November 2020. These information management systems would not be possible without the data and the work done on this Lean initiative. The requisitions process will become fully automated, and the demand and supply of materials will be managed similar to how it is done in manufacturing. The Mercury CI journey continues with gusto and Procurement plays its part.

MERCURY

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Company Overview | PM Group | pmgroup-global.com

PM Group manages the design, construction and commissioning of high-tech facilities. We are an employee-owned company with over 48 years' experience working for the world's leading pharma, food, data centre, and medical technology companies. We deliver projects across Europe, the USA, and Asia.

Authors

Colum Lynch

Michael Kerr

Overview & Background to the Lean Initiative

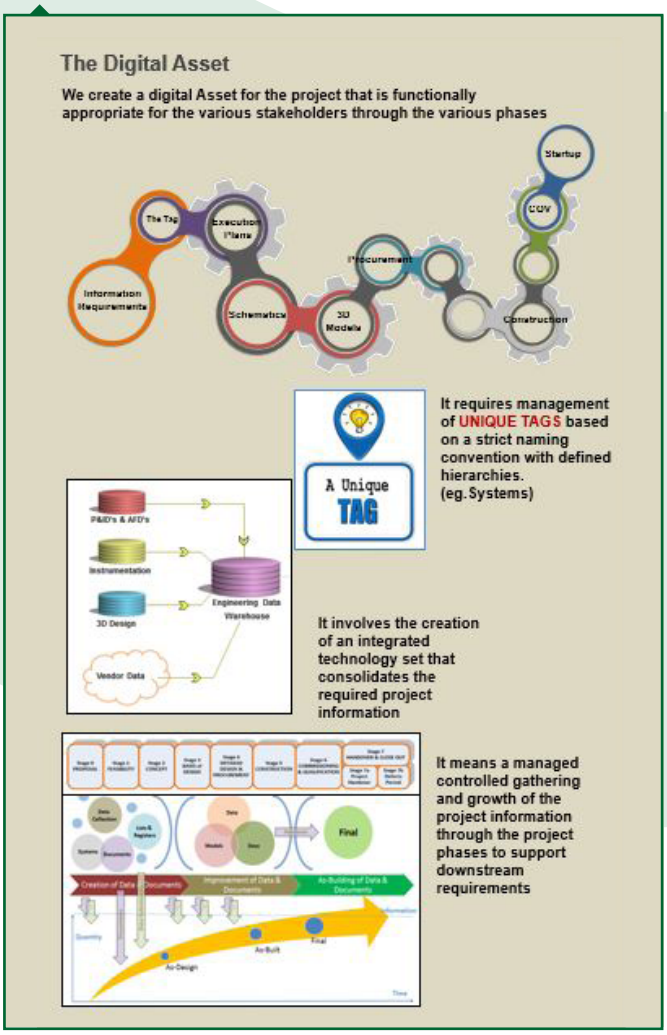
PM Group has an established reputation for developing and implementing innovations that solve our clients' business challenges and result in enhanced performance, flexibility, and competitiveness. Since our foundation in 1973, our products and services have been focused on providing design, construction, and commissioning services that deliver the physical assets that enable our clients, in turn, to provide their own products and services. Digital enabled Project Delivery (DePD) now enables us to provide a full digital asset in additional to the physical one.

This most recent DePD innovation expands our delivery capability further. However, what sets this apart from previous innovations is the fusion of Lean thinking and practices which has resulted in the following:

- Innovations in our products and services – we now couple the digital asset to that of the physical asset.
- Innovations in our delivery process – the elimination of non-value-added activity.
- Innovations in the way we organise and manage people – earlier and extended engagement of the entire project delivery community.

These DePD innovations, have exposed additional synergies in performance, flexibility, and competitiveness that extract further beneficial use from all the innovations on which this implementation of digital technology is built upon.

Figure 1. Digital enabled Project Delivery (DePD)



Lean Initiative Undertaken – Lean Thinking, Tools, Techniques

This digital asset has enabled us to innovate the project delivery process. Greater levels of trade partner involvement, off-site manufacture (OSM), and modularisation are now possible. This results in less waste, as well as simpler, safer, and higher quality construction. Commissioning starts much earlier in the virtual space of the digital asset and enables commissioning to influence design and construction. This avoids the waste associated with being constrained by a late start and fixed finish.

The ability to see the digital asset earlier has had a profound influence on quality and customer satisfaction. This front-end loading of design facilitates positive change at a point when the cost of change is minimal – a few keystrokes versus strip-out and re-fabricate. The DePD process exposed an opportunity to use the digital asset product created to support a number of Lean techniques for the construction group.

Advanced Work Package Planning incorporating Takt Planning Methods

This technique involved the assignment of appropriate construction areas to the project. These construction areas were further divided by trade partner scope. Once assigned, the areas are integrated with the construction schedule. Analysis of the schedule and scope allowed for an appropriate sequencing of work across the trades and areas to support the agreed schedule. The digital asset was used to support this technique.

The intelligent 2D schematics of the digital asset is integrated with the 3D model of the digital asset. This allowed for the scope of construction area work to be identified early in the 2D phase so that the 3D model was developed in alignment with the work package sequences of the schedule. This in turn allowed the tagged item data of the construction areas to be delivered to the procurement system to support the required delivery of equipment on-site per work package area and as per the construction sequence. This phased delivery of information and physical equipment supported the progressing of construction areas by our trade partners in the agreed sequence.

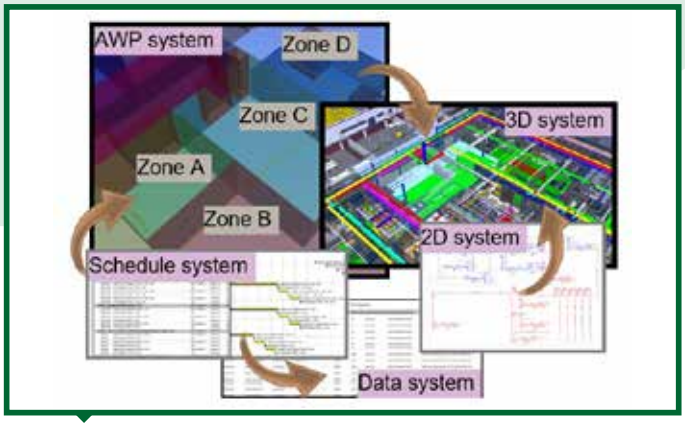


Figure 2. Advanced Work Package Planning

Paperless Receipt Verification

Coupled with the above initiative was the opportunity to use the information to support a paperless receipt verification process. The delivery of equipment and information was forecasted and executed based on the agreed schedule from the advanced work package process. The as-specified information moved from the design section of the digital asset to the construction management section. The construction management system supported our Lean process via the use of mobile devices configured to present the as-specified information for equipment to the user as a digital check sheet. The mobile device allowed for electronic signatures and photographs to verify the completeness of the paperless verification activity.

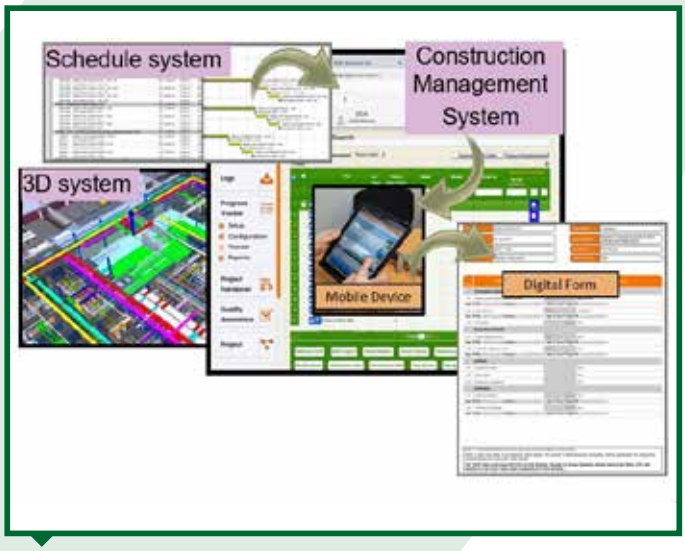


Figure 3. Paperless System

Early Computerised Maintenance Management System (CMMS)

The DePD process allowed us to create datasets from the managed project data for loading into the client's maintenance management systems. This preloading of data followed the system release schedule from the commissioning phase and hence allowed for maintenance activities to be appropriately set-up and ready for start-up. This initiative has reduced the duplication of effort associated with CMMS build activities and increased the quality of the information available.

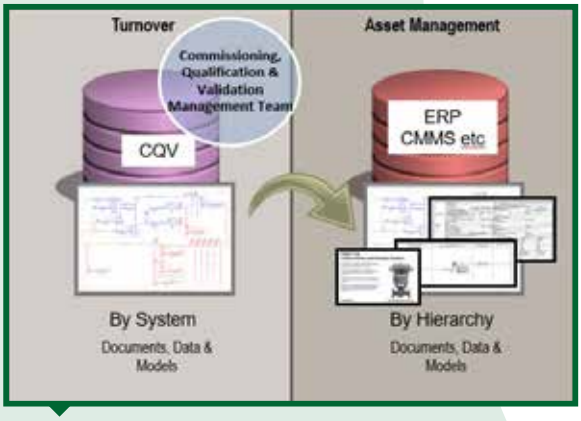


Figure 4. PM Group and Client Systems Alignment

These innovations in product and process have further enabled other organisation innovations such as:

- Greater outsourcing of design.
- Earlier and extended engagement of trade contractors.
- Commissioning staff and end users.
- Life-cycle package management.
- Greater integration of equipment vendors.

Lean Initiative Improvements & Impact

The project delivery organisation has evolved from a series of mini siloes where project delivery is advanced and handed-off in large batches of activity in defined sequence. DePD has enabled the project delivery organisation to more resemble a community of practice. The organisation and people management are focused on enabling the multitude of relationships necessary to support the project scope being defined, designed, constructed, and commissioned in a way that minimises waste and fully leverages the entirety of the human potential involved. It thus replaces the traditional contractual and adversarial approach that often optimised the parts to the detriment of the whole.

The digital asset also extended the delivery process to customers beyond the traditional handover of the physical asset – the digital asset enables the competitive exchange of services to client operational business units. It has been quite typical for clients to expend significant waste in extracting information from handover documentation to transfer it to other systems. This waste can be virtually eliminated by appropriately using the digital asset to configure the information in the required format for an error-free transfer that can additionally preserve embedded meta-information.

Management commitment and endorsement of digital project delivery was agreed when PM Group bid the current project. This meant that the expectation of improved performance was built into the project delivery expectations from the start. Previous projects had demonstrated/piloted the potential of DePD, and the decision to comprehensively apply DePD to the latest project was fully supported.

The Project Execution Plan was supplemented with a full suite of Digital Project Execution Plans that described how the project would be delivered. These plans were used to engage and communicate with the full project team so that all design disciplines and all support functions such as procurement and project controls were on board with the change and aware of how it would benefit them and how they could support the implementation.

Additional benefits include:

- A Steering Team was put in place with senior management that met weekly to maintain the focus and ensure the levels of commitment were maintained, to address gaps or challenges, and also to communicate the benefits of digital delivery to the wider organisation.
- Weekly clinics were put in place to deal with specific 'digital issues' that arose. An example includes sessions with package engineers and vendor to align information delivery expectations.
- A comprehensive training program was introduced for all on-boarded project participants, and Department Managers were included to ensure support.
- The project organisation included two full-time roles: a Digital Delivery Champion, and a Lean Delivery Champion. The former to provide the technical transformation and the latter to ensure the changes in work practice and subsequent elimination of waste were realised.

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CHAPTER 2

Glossary of Terms & Concepts

A3

This is a one-page report prepared on a single sheet of paper that adheres to the discipline of PDCA thinking as applied to collaborative problem solving, strategy development, or reporting. The A3 includes the background, problem statement, analysis, proposed actions, and the expected results.

Activity

An identifiable chunk of work with recognised prerequisite requirements to begin, plus a recognised state of completion or condition of satisfaction. Another way to look at an activity is to establish the hand-offs for each chunk of work, thus defining the activity.

Agile

In software development, "Agile" is the method of project management characterised by the division of tasks into short phases of work and frequent reassessment and adaptation of plans. It is an iterative approach to project management and software development that helps teams deliver value to their customers faster and with fewer headaches. Instead of betting everything on a "big bang" launch, an agile team delivers work in small, but consumable, increments. Requirements, plans, and results are evaluated continuously so teams have a natural mechanism for responding to change quickly.

Agility

This refers to supply chains and their management, and essentially means "readiness to change". From a business perspective, agility is defined as a strategy that is more responsive in a volatile marketplace, where this strategy is totally demand driven and the whole supply chain management changes as consumer buying patterns change at a very rapid pace. The fundamental drivers of agile supply chain are Speed, Cost, and Efficiency, and agile supply chains are based on the sensitivity to consumer demand, with sensitivity referring to the ultimate consumer demand in terms of the volatility of that demand. Agile supply chain framework is based on four major constituents: (i) Virtual Integration; (ii) Process Alignment; (iii) Network-Based; and (iv) Market Sensitive.

Assignment

A request or offer that has resulted in a reliable promise and is ready to be placed on the weekly work plan for performance. An assignment must meet the characteristics for a quality assignment prior to inclusion on the weekly work plan.

Buffer

A mechanism for deadening the force of reality unfolding in a manner that is contrary to what was anticipated in the plan. For example, a capacity buffer is created by committing to complete less work than what would be achieved according to the planned capacity of the resource. If production falls behind schedule, there is capacity available for catching up. Lean production/construction generally prefers capacity buffers to inventory buffers.

Building Information Model/Modelling (BIM)

The process of generating and managing building data during the life cycle of a building. BIM uses three-dimensional (3D), real-time, dynamic building modelling software. BIM includes building geometry, spatial relationships, geographic information, and quantities and properties of building components. BIM can include four-dimensional (4D) simulations to see how part or all of the facility is intended to be built and 5D capability for model-based estimating. BIM provides the platform for simultaneous conversations related to the design of the "product" and its delivery process.

Capacity

The amount of work that can be produced by an individual, specialist, or work group in a given period of time.

Choosing By Advantages (CBA)

This is a tested, effective, and sound decision-making system developed by Jim Suhr (1999) for determining the best decision by looking at the advantages of each option. CBA has five phases of decision-making: (1) Stage-setting: establish the purpose and context for the decision; (2) Innovation: formulate an adequate set of alternatives; (3) Decision-making: choose the alternative with the greatest total importance of advantages; (4) Reconsideration: change the decision if it should be changed or improved on; (5) Implementation: make the decision happen, adjust as needed, and evaluate the process and results.

Commitment-Based Planning

A planning system that is based on making and securing reliable promises in a team setting.

Conditions of Satisfaction (CoS)

An explicit description by a customer of all the actual requirements that must be satisfied by the performer in order for the customer to feel that they received exactly what was wanted.

Constraint

An item or requirement that will prevent an activity from starting, advancing, or completing as planned. Typical constraints on design tasks are inputs from others, clarity of requirements criteria for what is to be produced or provided, approvals or releases, and labour or equipment resources. Typical constraints on construction tasks are the completion of design or prerequisite work, or availability of materials, information, and directives. Screening tasks for readiness is assessing the status of their constraints. Removing constraints is making a task ready to be assigned.

Constraints Log

A list of constraints with identification of an individual promising to resolve the item by an agreed date. Typically developed during a review of the 6-week look-ahead plan when it is discovered that activities are not constraint free.

Continuous Improvement (CI)

This is "Kaizen" in Japanese, and it refers to the never- ending cycle of incremental efforts to improve products, services, and processes. Lean is a CI methodology and Lean's 5th Principle of "Seek Perfection" and "PDCA" speak to CI.

Corrective Action Preventive Action (CAPA)

This is a process that investigates and solves problems, identifies causes, takes corrective action, and prevents recurrence of the root causes. The ultimate purpose of CAPA is to ensure that the the problem can never be experienced again.

Cost Modelling

Developing a model of the cost components and systems specific to a project and structuring it in a manner that the components and system costs can be continually updated either via benchmarks, metrics, or detailed estimates, to provide the team with a constantly up to date cost model for the project. In the TVD environment, the cost model should allow for projecting "what-if" scenarios based on value decisions that have yet to be made.

Critical Path Method (CPM)

The critical path method is a step-by-step project management technique to identify activities on the critical path. It is an approach to project scheduling that breaks the project into several work tasks, displays them in a flow chart, and then calculates the project duration based on estimated durations for each task. It identifies tasks that are critical, time-wise, in completing the project.

Critical To Quality (CTQ)

These are the key measurable characteristics of a product or process whose performance standards or specification limits must be met in order to satisfy the customer. CTQs represent the product or service characteristics as defined by the customer/user.

Current State Map

This is a snapshot of how a process is currently done, showing the current methodology of how you produce products or perform services for your customers. It is a visual method of succinctly recording the key aspects of the current structure and processes in the whole, or any part, of a supply chain.

Customer

The individual engaged in a conversation for action who will receive the results of performance either requested from, or offered by, the performer. That is, the person receiving goods/ information from a performer. Customers can be internal (for example, a foreman receiving answers to an RFI; or an architect receiving mechanical loads from an engineer), and external (for example, end users or client organisations).

Cycle Time

The time it takes a product or unit of work (for example, a room, building, quadrant) to go from beginning to completion of a production process. That is, the time it is work-in-process.

Defined Task

A quality task must be "defined". It must have a beginning and end, and it should be clear to all when it has been completed.

Dependence

This refers to where two or more tasks are sufficiently related that one cannot be started (or finished) without a certain measure of progress or completion having been achieved by the other. Waiting on release of work.

Direct Observation

Also known as "Observational Study", this is a method of collecting evaluative information in which the evaluator watches the subject in their usual work environment without altering that environment.

DMAIC

Define, Measure, Analyse, Improve, and Control. DMAIC is a data-driven improvement cycle used for improving, optimising, and stabilising business processes and designs. The DMAIC improvement cycle is the core tool used to drive Six Sigma projects.

Earned Value (EV)

This is an approach involving monitoring the project plan, actual work, and work completed value, to see if a project is on track. Earned Value shows how much of the budget and time should have been spent, considering the amount of work done so far.

Eight Wastes

A framework of eight types of activity that do not add value – thus they are "Waste". They can be summarised as "DOWNTIME" (Defects, Over-Production, Waiting, Non-utilised resources/talent, Transportation, Inventory, Motion, Excess-Processing); or as "TIMWOODS" (Transportation, Inventory, Motion, Waiting, Over-Production, Over-Processing, Defects, Skills).

Enterprise Resource Planning (ERP)

This is the integrated management of core business processes, often in real-time, mediated by software and technology, and providing an integrated and continuously updated view of core business processes using common databases.

Expected Cost

An expression of the team's best estimate at the conclusion of the Validation Phase of what current best practice would produce as a price for the facility reflected in the accompanying basis of design documents. Typically, the Expected Cost will also be supported by benchmarking or other market data to calibrate the Expected Cost in light of the market context.

Fishbone Diagram

This was developed by Ishikawa – often referred to as an "Ishikawa Diagram" – and is a cause-and-effect diagram used in root cause analysis to better understand the factors contributing to a problem..

Five Big Ideas

A set of organising concepts that support Lean Project Delivery. They were developed to explain and organise the Sutter Health Lean Construction Initiative: Optimise the project not the piece, Collaborate, Really Collaborate (originally implied "specialty contractors involved at schematic design"), Projects as Networks of Commitment, Increase Relatedness, and Tightly Couple Action and Learning.

Five Core Principles

These are the core principles underpinning Lean that were developed by Womack and Jones (1996), and include:

i. Value – It is defined by your customers who buy results not products (clean clothes vs. washing machines). We should give the customer what they want rather than what is convenient for us to give them.

ii. Value Stream – The sequence of all processes from raw material to customer.

iii. Flow – Keep value moving; avoid batches and queues; there should be few non-value-adding steps.

iv. Pull – Short-term response to customer's rate of demand and no over-production.

v. Perfection – Delivering exactly what a customer wants, when they want it, at a fair price, and defect-free, with minimum waste.

5S

(1) Sort; (2) Set in order; (3) Shine; (4) Standardise; (5) Sustain. This five-step process for workplace efficiency uses visual controls to eliminate waste, and helps us organise what we need and to eliminate what we don't need, thus allowing us to identify problems quickly.

5 Whys

An iterative questioning technique, using cause-and-effect analysis, to get to the root cause of a problem by asking why successively whenever a problem exists in order to get beyond the apparent symptoms. As each answer to the "why" question is documented, an additional enquiry is made concerning that response.

Flow

Movement that is smooth and uninterrupted, as in the flow of work from one crew to the next or the flow of value at the pull of the customer.

Future State Map

A vision of the desired future Lean system that is used as the guide for the change process.

Gemba

This is the Japanese term for the place where the actual work is done and where actual value is added. Lean experts encourage "going to the gemba" to see how things are really done and where there is opportunity to eliminate or reduce waste. Gemba is the practice of leaders going to the place where work is done to observe, ask questions, and show respect. Gemba walks should be done with purpose and focus on understanding and improving processes, not evaluating employee performance. After a walk is complete and the leader has the chance to reflect, action is taken regarding any opportunities for improvement that were discovered.

Hand-Off

The act of releasing an item or activity to the person or group performing the next step or operation on that item or activity, for example, a structural steel design is handed-off to the steel detailer to complete shop drawings; a room (or portion) that has been framed is handed-off to the drywall installer; or all construction on a floor of a hospital is completed and handed-off to the hospital personnel to begin staff-and-stock activities.

Hoshin Kanri

This the Japanese term for direction management or strategy deployment – Ho means direction; Shin means Focus; Kan means Alignment; Ri means reason. Hoshin Kanri is the practice of identifying the organisation's long-term breakthrough objectives and aligning the goals and decisions of every person in the organisation. Strategy deployment is not an annual event, and success requires that it become operationalised at every level and incorporating strategy deployment into leader standard work to set a schedule for reviewing progress toward the objectives and managing KPIs on a daily basis. At any point, a leader should be able to say where their team is on the path toward its stated monthly, quarterly, and annual objectives.

Huddle Meetings

Huddle meetings give employees the opportunity to identify challenges and work on problem solving skills. They should be part of leader standard work because they give managers and supervisors early insight into potential problems and the opportunity to coach the team on how to implement positive change.

Integrated Form of Agreement (IFoA)

A multi-party agreement that includes the owner, design professional, and constructor as signatories to the same construction contract.

Integrated Project Delivery (IPD)

A project delivery approach that integrates people, systems, business structures and practices into a process that collaboratively harnesses the talents and insights of all participants to reduce waste and optimise efficiency through all phases of the project, from early design through project handover. The three contractual components of IPD include: Organisation Structure, Lean Operating Systems, and Commercial Terms.

Just In Time (JIT)

A system for producing or delivering the right amount of parts or product at the time it is needed for production.

Kaizen

The Japanese term for incremental continuous improvement. Kaizen is a structured process to engage those closest to the process to improve both the effectiveness and efficiency of the process. Its goals are to remove waste and add standardisation. Kaizen has come to mean the philosophy of continuous improvement.

Kanban

The Japanese term for a signposting mechanism associated with the demand pull principle. The signal tells workers to pull parts or refill materials to a certain quantity used in production, and is a signal that a downstream or customer process can use to request a specific amount of a specific part from the upstream or supply process. It is a visual system for managing work as it moves through a process, and it visualises both the process (the workflow) and the actual work passing through that process. The goal of Kanban is to identify potential bottlenecks in your process and fix them so work can flow through it cost-effectively at an optimal speed or throughput.

Key Performance Indicators (KPIs)

These are a set of measures designed to benchmark a business's most important characteristics against a set of strategic targets.

Last Planner

Integral to the LPS, this is the person or group that makes assignments to direct workers. Project Architect and Discipline Lead are common names for last planners in design processes; and Superintendent or Foremen are common names for last planners in construction processes.

Last Planner® System (LPS)

The complete term is "Last Planner System for Production Control". This is a system for project production planning and control that is aimed at creating a workflow that achieves reliable execution. It was developed by Glenn Ballard and Greg Howell, with documentation by Ballard in 2000. LPS is the collaborative, commitment-based planning system that integrates should-can-will-did planning: pull planning, make-ready look-ahead planning with constraint analysis, weekly work planning based upon reliable promises, and learning based upon analysis of PPC and Reasons for Variance.

Last Responsible Moment (LRM)

The instant in which the cost of the delay of a decision surpasses the benefit of delay; or the moment when failing to take a decision eliminates an important alternative.

Leader Standard Work

This applies the concept of standard work to the task of driving Lean thinking and behaviour throughout the organisation. Leader standard work is a set of actions, tools, and behaviours that are incorporated into the daily activities of leaders at all levels. Like the standard work for any process, leader standard work must be documented, practiced consistently, and changed only with reflection and experimentation.

Lean

The concept that all processes contain waste. Lean is a value-driven and integrated approach to designing and improving work towards a customer-focused ideal state through the engagement of all people aligned to common principles and practices. It is associated with the ability to accomplish more with less – Lean Enterprises use less human effort to perform their work, less material to create their products and services, less time to develop them, and less energy and space to produce them. It is underpinned and sustained by a culture of respect and continual improvement aimed at creating more value for the customer while identifying and eliminating waste.

Lean Construction

This is a respect-oriented and relationship-oriented production management-based approach to capital project delivery. It is an alternative and transformational way to design and build capital facilities versus traditional construction design and project management.

Lean Project Delivery System (LPDS)

An organised implementation of Lean principles and tools combined to allow a team to operate in unison to create flow.

Lean Thinking

The philosophical foundation, leadership mindset, and management orientation that enables all individuals in an organisation to understand "Real Lean", and to design, develop, implement, manage, and sustain a Lean Enterprise and culture of proactive problem solving and continuous improvement.

Load

The amount of output expected from a production unit or individual worker within a given time.

Look Ahead Plan

A short interval plan, based on the pull/phase plan, that identifies all the activities to be performed in the next 6 (or

other) weeks. The 6-week look-ahead is updated each week – always identifying new activities coming 6 weeks out so that the project management team can make appropriate arrangements to assure that the work will be ready to be performed in the week indicated.

Look Ahead Planning

The portion of the LPS that focuses on making work ready – assuring that work that should be done, can be done, by identifying and removing constraints in advance of need.

Look Ahead Window

The duration associated with look ahead planning. Typically look ahead windows extend from 3 to 12 weeks into the future, with 6 weeks preferred on most projects.

Make Ready Process

To make ready is to take actions needed to remove constraints from assignments to ensure the work can be done as planned.

Master Schedule

A schedule that identifies major events or milestones in a project (for example, start- up, turn-over to client, order long delivery components, mobilise in field, complete design, government reviews) and their timing. It is often the basis for contractual agreements between the owner and other team members. It is seen as a way to identify long lead items, the feasibility of completing the project as currently required, the basis for defining milestones and phases – but not always as a way to control the project.

Milestone

An item on the master schedule that defines the end or beginning of a phase or a contractually required event.

Muda

This is the Japanese word for "Non-Value-Adding" or "Waste" and refers to any activity that consumes resources but adds no value. They are a target for reduction or elimination. All Muda is caused by Mura and/or Muri.

Mura

This is the Japanese word for "Unevenness", namely any activity that has not been levelled out creating consequential complexity and cost. They are a target for reduction or elimination.

Muri

This is the Japanese word for "Overburdening", namely any activity that causes excessive demand on a system that causes the system to produce beyond its reasonable capacity. Pushing a machine or person beyond natural limits. Overburdening people results in stress, safety, and quality problems. Overburdening equipment causes breakdowns and defects. They are a target for reduction or elimination.

Necessary Non-Value-Adding (NNVA)

Those support activities/processes that are necessary under the present operating system or equipment but which do not, per se, add value. One should seek to optimise these.

Network of Commitments

The web of promises necessary to deliver any project. The role of management is to articulate and activate the unique network of commitments required to deliver each project.

Non-Value-Adding (NVA)

Those activities/processes that do not directly add/contribute value to customers – namely those activities the customer would not be happy to pay for. One should seek to reduce or remove these.

Optimal Equipment Effectiveness (OEE)

This is a hierarchy of metrics to evaluate how effectively a manufacturing operation is utilised with results stated in a generic form which allows comparison between manufacturing units in differing industries. It is not an absolute measure and is best used to identify scope for process performance improvement. It is a composite measure of the ability of a machine or process to carry out value adding activity. OEE = % time machine available * % of maximum output achieved * % perfect output. It measures the degree to which machines are adding value by not being wastefully employed due to planned or unplanned downtime or in producing defects.

Pareto Analysis

Sometimes referred to as the "80:20 rule", this is the tendency in many business situations for a small number of factors to account for a large proportion of events. For example, 80% of total sales volume might be attributable to 20% of customers and 20% of the product range. In terms of quality, 80% of defects might be attributable to 20% of causes. The 20% is sometimes referred to as "the vital few".

PDCA

Plan, Do, Check, Act/Adjust. This is the cycle introduced by Walter A. Shewhart and popularised by Dr W. E. Deming as a method for continuous improvement.

Percent Plan Complete/Planned Percent Complete (PPC)

A basic measure of how well the planning system is working – calculated as the number of promises/activities completed on the day stated divided by the total number of promises/activities made/planned for the week. It measures the percentage of assignments that are 100% complete as planned

Performer

The individual engaged in a conversation for action who agrees to undertake performance either requested from or offered to a customer.

Phase

A period of the project where a specific group of activities

is scheduled to be accomplished such as building design, completion of foundations, erection of exterior walls, building dry-in. A phase can be either a time period or a group of activities leading to the accomplishment of a defined goal/ milestone.

Phase Plan

A plan for executing a specific phase of a project using a pull technique to determine hand-offs. It is prepared by the team actually responsible for doing the work through conversation. Work is planned at the request/demand of a downstream customer.

Plan Reliability

The extent to which a plan is an accurate forecast of future events - it is measured by PPC.

Planning

The act of conversation that leads to well-coordinated action.

Plus/Delta Review

A continuous improvement discussion performed at the end of a meeting, project or event used to evaluate the session or activity. Two questions are asked and discussed. Plus: What produced value during the session? Delta: What could we change to improve the process or outcome?

Poka-Yoke

A Japanese term for mistake-proofing method or device developed by Shigeo Shingo that is used to prevent an error or defect from happening or being passed on to the next operation.

Personal Protective Equipment (PPE)

Integral to health and safety, this is the equipment worn to minimise exposure to serious workplace injuries and illnesses.

Process Mapping

A flowchart identifying all the activities, operations, steps, and work times for a process.

Promise

The action taken by a performer to commit to a customer to take some action to produce a mutually understood result, for example CoS, by a definite time in the future.

Pull

A method of advancing work when the next-in-line customer is ready to use it. A request/demand from the customer signals that the work is needed and it is pulled from the performer. Pull releases work when the system is ready to use it.

Push

Push an order from a central authority based on a schedule; advancing work based on central schedule. Releasing materials, information, or directives possibly according to a plan but irrespective of whether or not the downstream process is ready to process them.

Quality

Quality denotes an excellence in goods and services, especially to the degree they conform to requirements and satisfy customers.

Quality Assignment

Assignment that meets quality criteria for release to the customer process. The quality criteria are: (1) definition; (2) soundness; (3) sequence; (4) size; and (5) learning.

Reason for Variance

Factors that prevented an assignment from being completed as promised, used by the team to promote learning concerning the failure of the planning system to produce predictable workflow. By assigning a category of variance to each uncompleted task, a team is able to identify those areas of recurring failure that require additional reflection and analysis.

Reliable Promise

A promise made by a performer only after self-assuring that the promisor: (1) is competent or has access to the competence (both skill and wherewithal); (2) has estimated the amount of time the task will take; (3) has blocked all time needed to perform; (4) is freely committing and is not privately doubting ability to achieve the outcome; and (5) is prepared to accept any upset that may result from failure to deliver as promised.

Request

The action taken by a customer to ask a performer to take some action to produce a mutually understood result (CoS) by a definite time in the future.

Right First Time (RFT)

This concept involves ensuring that all activities/processes are carried out in the right manner the first time and every time. A quality management concept that defect prevention is more advantageous and cost effective than defect detection and associated rework.

Root Cause Analysis

Integral to Lean tools and techniques, and the essence of problem solving, this is a systematic method of analysing possible causes to determine the root cause of a problem.

SCAMPER

The SCAMPER technique is based very simply on the idea that what is new is actually a modification of existing old things around us. It is a creative thinking and problem solving technique developed to address targeted questions that help solve problems or ignite creativity during brainstorming meetings. The name SCAMPER is acronym for seven techniques: (S) substitute, (C) combine, (A) adapt, (M) modify, (P) put to another use, (E) eliminate, and (R) reverse.

Screening

Determining the status of tasks in the look-ahead window relative to their constraints, and choosing to advance or retard tasks based on their constraint status and the probability of removing constraints.

Scrum

Linked to Agile, and initially utilised in software development, Scrum is a framework for developing, delivering, and sustaining complex products, within which people can address complex adaptive problems while productively and creatively delivering products of the highest possible value. Scrum meetings encompass the essence of Lean Huddle Meetings and Leader Standard Work.

Sequenced

A sequenced assignment should release work to another performer, and in no case should it hinder another assignment or cause other crews to do additional work. It refers to quality criterion for selecting assignments among those that are sound in priority order and in constructability order.

Set-Based Concurrent Engineering (SBCE)

This emanated from the Toyota Motor Corporation's approach to product development. SBCE begins by broadly considering sets of possible solutions and gradually narrowing the set of possibilities to converge on a final solution. A wide net from the start, and gradual elimination of weaker solutions, makes finding the best or better solutions more likely. As a result, a company/design team may take more time early on to define the solutions, but can then move more quickly toward convergence and, ultimately, production than its point-based counterparts.

Set-Based Design (SBD)

A design method whereby sets of alternative solutions to parts of the problem are kept open until their last responsible moment (LRM) in order to find by means of set intersection the best combination that solves the problem as a whole.

Shielding

Preventing the release of work to production units because it does not meet quality criteria - the work is not a quality assignment. It is akin to stopping the assembly line rather than advancing a defective product. The purpose of shielding is to reduce uncertainty and variation, thereby providing production units with greater opportunity to be reliable.

Should-Can-Will-Did

To be effective, production management systems must tell us what we should do and what we can do, so that we can decide what we will do, then compare with what we did to improve our planning.

SIPOC

Suppliers, Inputs, Process, Outputs, Customers. This is a visual tool to assist in documenting a process from beginning-to-end.

6S

This is all of the 5S with the addition of Safety as the 6th S.

Six Sigma

A method and a set of tools to reduce variation in processes, particularly quality, using mostly statistical tools.

Sized

Quality criterion for assignments whereby the amount of work included in an assignment is made to match the capacity of the production unit that will do the work. The performer should have a very reasonable expectation that the assignment can be completed by the number of people available to do the job.

SMED

Stands for Single Minutes Exchange of Dies. It is a Lean production method to enable improved line changeovers and reduce the waste therein.

Sound

Quality criterion for assignments that tests whether or not assignments have had all constraints removed. The performer of an assignment should know that the materials, tools, staff, and information to complete an assignment are available before accepting it.

Standard Work

Integral to Lean thinking and practice, this aims at creating standardised processes and procedures that are repeatable, reliable, and capable – this being the basis for continuous improvement. It is the documented and current best way to do a particular task, procedure, or process. Workers develop the standard and follow it until an improvement process results in a new standard. Standard work ensures that results are consistent and forms the foundation upon which improvements are made.

Takt

The German word for "beat", Takt time may be thought of as a measurable beat time, rate time, or heartbeat. In Lean, Takt time is the rate at which a finished product needs to be completed in order to meet customer demand. If a company has a takt time of 10 minutes, that means every 10 minutes a complete product, assembly, or machine is produced off the line because on average a customer is buying a finished product every 10 minutes.

Target Cost

The cost goal established by the delivery team as the target for its design and delivery efforts. The Target Cost should be set at less than best-in-class past performance. The goal is to create a sense of necessity to drive innovation and waste

reduction into the design and construction process.

Target Value Delivery (TVD)

This is a disciplined management practice to be used throughout the project to ensure that the facility meets the operational needs and values of the users, is delivered within the allowable budget, and promotes innovation throughout the process to increase value and eliminate waste (time, money, human effort).

Target Value Design

Encompasses the Target Value Delivery approaches implemented during the design delivery phases of the project.

Target Value Production

Encompasses the Target Value Delivery approaches implemented during the construction delivery phases of the project.

Task

An identifiable chunk of work.

Throughput

This is the output rate of a production process, and refers to the amount of material or items passing through a system or process.

Total Productive Maintenance (TPM)

This is a technique designed to optimise the performance, reliability, and productivity of plant and equipment. Responsibility for maintenance is given to the actual operators.

Under-Loading

Making assignments to a production unit, or a resource within a production unit, that absorbs less than 100% of its capacity. Under-loading is necessary to accommodate variation in processing time or production rate, in order to ensure plan reliability. Under-loading is also done to release time for workers to take part in training or learning, conducting first-run studies, implementing process improvements, or for equipment to be maintained.

Utilisation

The percentage of a resource's capacity that is used in actual production.

Value

This is the start, middle, and end point of Lean. Value refers to what the customer wants from the process – the customer defines value – and is captured through the "Voice Of Customer".

Value-Adding (VA)

Those activities/processes that directly add to or contribute value to customers – those activities the customer is happy to pay for. One should constantly strive to expand these.

Value Stream

The sequence of activities required to design, produce, and deliver a good or service to a customer, and it includes the dual flows of information and material.

Value Stream Mapping (VSM)

The process of mapping out and visually displaying a value stream so that improvement activity can be effectively planned. VSM is the meta tool that guides all other Lean tools. When we utilise VSM we visualise the current state plus desired future state of a process that take a product or service from its beginning through to the customer.

Variance

In statistics, Variance ($\sigma 2$) is a measurement of the spread between numbers in a data set. That is, it measures how far each number in the set is from the mean (expected value/average) and therefore from every other number in the set. When an assignment is not completed as stated, it is considered a variance from the daily/weekly/monthly work plan.

Variance Trend Analysis

This refers to the quantitative investigation of the difference between actual and planned behaviour. This technique is used for determining the cause and degree of difference between the baseline and actual performance and to maintain control over a project.

Visual Management

Placing tools, parts, production activities, plans, schedules, measures and performance indicators in plain view. This ensures that the status of the system can be understood at a glance by everyone involved and actions taken locally in support of system objectives.

VUCA

This stands for Volatile, Uncertain, Complex, Ambiguous, and it describes the situation of constant, unpredictable change that is now the norm in certain industries and areas of the business world. VUCA demands that we avoid traditional and outdated approaches to management, leadership, and day-to-day working.

Waste

The opposite of value, these are activities/processes that do not directly add/contribute value to customers, and that the customer would not be happy to pay for. The aim of Lean is to reduce and remove waste from processes.

Waste Walks

These are "Gemba Walks" and are a form of direct observation and simply entail a planned visit to where work is being performed to observe what's happening and to note the waste. It differs from go-see activities in that you are specifically looking for waste.

Weekly Work Plan (WWP)

The commitment-level (will) planning step of LPS identifying the promised task completions agreed upon by the performers. The WWP is used to determine the success of the planning effort and to determine what factors limit performance. It is a more detailed level than the look-ahead and is the basis of measuring PPC.

Weekly Work Planning

The process by which the Last Planner establishes the plan for the coming period.

Work Flow

The movement of information and materials through networks of interdependent specialists.

Work Structuring

Designing the production system to determine who does what, when, where and how, usually by breaking work into pieces, where pieces will likely be different from one production unit to the next. The purpose of work structuring is to promote flow and optimise system throughput by focusing on handoffs and opportunities for moving smaller batches of work though the production system.

Workable Backlog

An activity or assignment that is ready to be performed, but is not assigned to be performed during the active week in the WWP. If the team agrees that performance of this activity will not hinder other work, then it can be placed on the list of Workable Backlog as part of the WWP. Completion or non-completion of these activities are not recorded or counted in calculation of PPC.

Work In Process (WIP)

The inventory between the start and end points of a production process.

X-Matrix

Used in Hoshin Planning, the X-Matrix is a template used in organisational improvement that concisely visualises on one page (A3) the alignment of an organisation's True North, its Aspirations, its Strategies, its Tactics, and its Evidence.

Editor's Note

This glossary has been compiled and adapted from a variety of sources, primarily the WIT Glossary of Lean Terms & Concepts and the LCI (USA) Glossary of Terms.

EXO Building
Image Courtesy of Linesight