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Mace Technology (Ireland) 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

Ireland 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, Eirgrid, and Facebook.

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Overview & Background to the Lean Initiative

This study was carried out on a hyper-scale data centre that entailed both design and build and design-bid-build phases. Preparation and approval of design documentation is a key factor for managing an efficient production control system. Construction projects are complex projects that involve multi-disciplined stakeholders with the preparation and coordination of design activities in line with strategic milestones. Design is linked to construction activities and then through to inspection and quality control. Design teams and construction teams need to collaborate to create and verify design documentation before procurement and site installation and inspection. Team fragmentation has been identified as a barrier for

efficient design management, and design teams, contractor supply teams, and vender supply chain are dispersed.

The Last Planner® System (LPS) was identified as a possible solution to managing contractor drawing and technical submission improvements. In parallel with Lean and BIM management, design deliverable dates were identified in advance of programmed construction dates. Shop drawings and technical submittals were prepared for review by the design team. This was managed in line with the construction programme which allowed planned works to proceed safely and in a timely manner.

Lean Initiative Undertaken – Lean Thinking, Tools, Techniques

Design Last Planner System

Construction is a series of actions undertaken by construction companies which produce or alter buildings and infrastructure. Individual construction companies become competent at one or more of the actions over many years, and they apply their specialised skills and knowledge on construction projects. The design and construction of buildings and infrastructure are undertaken by specialist design and construction professionals, and supported by an integrated network of suppliers and specialist contractors.

Integrating project teams to work collaboratively has increased productivity in construction. The lack of approved design documentation had been noted as a significant factor for missed assignments in the construction last planner process. Improved coordination between trade contractors, main contractor, and design teams was required to improve the delivery of approved design information in line with planned construction activities. To integrate design and construction activities, a design coordination and last planner meeting was scheduled weekly. The purpose of that meeting was to improve communication between construction and design teams. The meeting was structured to provide a coordinated look-ahead document preparation schedule. This was managed in line with the construction programme for the timely preparation of documents to ensure that there was an uninterrupted workflow for construction activities. The vision for all stakeholders is to deliver the highest quality project with all documentation complete and defect-free at practical completion. To achieve this, a collaborative approach

to design, construction, and inspection was required.

Design and Quality

At the interface between design and construction, the following questions accentuate:

- Has the design of the elements been completed?
- Have the necessary technical submissions and benchmarks been approved?

Work needs to be considered in greater detail as the make-ready process focusses on matching the available resources for work with the present realities on the construction site to ensure production can proceed at an optimum level. Information flows connect activities to design and quality to facilitate the make-ready process. Only when this is agreed can tasks be considered for execution in weekly work plans.

The importance of information management, and the ability to share information between project stakeholders to ensure that the project requirements are met, provides a robust platform for managing task allocations and sequencing.

The value-added data is one that supports the craft worker by ensuring that the planned works proceed uninterrupted and that any variance from the plan is forecast and mitigated to manage resource utilisation. This relationship between information and material flow suggests that design last planner improves the overall production

system by raising the efficiency of information logistical processes. The main challenge is to ensure the deliverables are issued in a timely fashion and at a standard to achieve approval right first time to allow works to progress in a timely fashion.

The traditional approach used the standard Information Release Schedule (IRS), which itemises all deliverables and their planned delivery dates. This normally results in the Package Managers having to spend a lot of resources to ensure their contractors deliver.

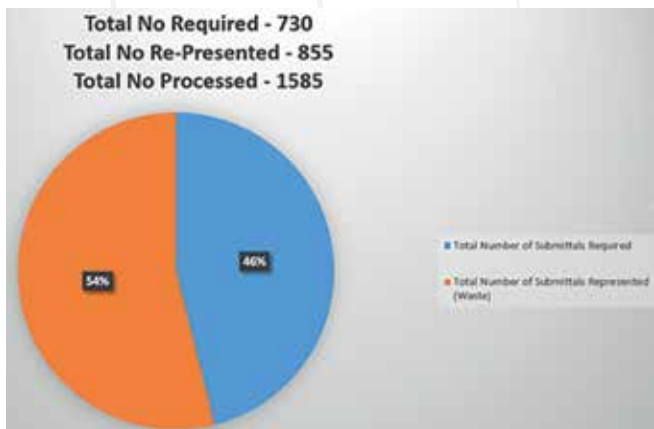


Figure 1. Submittal Production Waste

The delivery and management of the technical submittal reviews often proves protracted and inefficient due to the large number of stakeholders, from Contractors to Design Team and Client. A previous building phase, which utilised the IRS approach, required 730 technical submittals that resulted in these being presented a total of 1,585 times to achieve a Status A. Any technical submittal

presented more than once is considered waste. This was therefore identified as an area for improvement for site production as technical submittals are crucial for procurement and quality.

The design last planner improved coordination of site activities and the last planner meeting provided a means for an integrated trade contractor and general contractor design interface. The design activities were identified and prioritised by identifying the make-ready needs for the construction process.

Short-term work plans were developed wherein design constraints were identified and systematically removed to successfully complete design documentation in advance of trade contractor construction activities. Measuring planned percent complete (PPC) of planned design activities provided a more transparent and efficient means for tracking design productivity and improved the quality of the information produced. As principal contractor, the conditions of satisfaction were communicated to multiple contractor design teams and the collaborative nature of the process increased the quantity and quality of the documentation.

Therefore, this improved productivity on the project. Tasks were planned with greater certainty and the quality of the installations improved by adhering to the correct documentation. This in turn improved weekly work planning. When tasks are deemed to be sound, they can be considered for inclusion in the weekly work plans for production units on site. This process requires multi-disciplinary teams to coordinate production unit activities for the project. Team members who are making commitments were able to commit defined assignments and interact with other production units for trade-to-trade hand-overs and quality assurance inspection teams.

Lean Initiative Improvements & Impact

Prior to the submittal process, the Design Team and the Client was where the technical submittal requirements were agreed, which in turn were relayed to the Contracting Teams individually via a series of workshops. The Last Planner requirements and expectations with all stakeholders were communicated and agreed.

All contractors and the Design Team were required to prepare 6-week look-ahead plans and weekly work plans that itemised committed deliverables on a rolling week-by-week basis. Weekly meetings were set up to review the make ready needs to avoid pitch points and ensure smooth information flow. The teams were encouraged to act collaboratively and as one. Prior to the formal submission, the contractors were required to discuss with the design team the requirements and expectations.

This approach resulted in significant improvements in reductions to the number of iterations required to achieve a Status A, right first time, and in turn saw a substantial improvement to the ratio of waste.

Analysis to date is limited to work packages that have enough technical submittals presented, namely:

1. Civil.
2. Steels.
3. Mechanical.
4. Electrical.

Figure 2 encompasses the mechanical work package of the delivery of technical submittals of planned versus actual, and is representative of all work packages analysed to date.

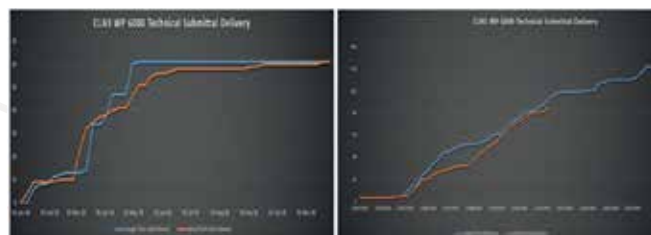


Figure 2. Package Delivery Planned Vs. Actual

The Mace Last Planner approach results in a smoother flow of information. It gives foresight to the Design Team of impending workloads, thus allowing provisions to be made to resource

manpower to meet the workload. It is also dynamic, allows for change to be accommodated, and enables ease of tracking.

Figure 3, for the mechanical services, compares the delivery of technical submittals iterations for the current phase to the previous phase and is representative of all work packages analysed to date.

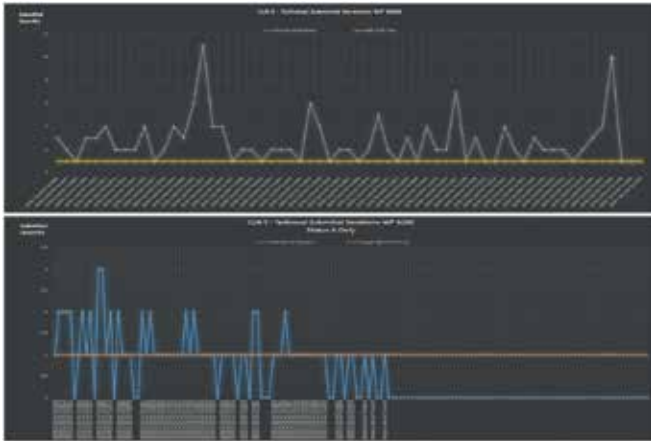


Figure 3. Technical Submittal Number of Iterations

The number of iterations required to achieve Status A has reduced and the quantity of technical submittals being approved right first time has also increased.

Right First Time Improvements

Civil Work Package WP 6009	CLN3	CLN5/6	Comment
Total No of Submittal Required	67	109	CLN5/6 Stats comparison for submittals received up to project working week 31
Total No Right First Time	39	55	
Percentage Right First Time	58%	50%	

Steels Work Package WP 2006	CLN3	CLN5/6	Comment
Total No of Submittal Required	20	27	CLN5/6 Stats comparison for submittals received up to project working week 31
Total No Right First Time	6	15	
Percentage Right First Time	30%	56%	

Mechanical Work Package WP 5001	CLN3	CLN5/6	Comment
Total No of Submittal Required	61	65	CLN5/6 Stats comparison for submittals received up to project working week 31
Total No Right First Time	17	48	
Percentage Right First Time	28%	74%	

Electrical Work Package WP 6006	CLN3	CLN5/6	Comment
Total No of Submittal Required	21	85	CLN5/6 Stats comparison for submittals received up to project working week 31
Total No Right First Time	3	62	
Percentage Right First Time	14%	73%	

Work Package Sample Totals	CLN3	CLN5/6	Comment
Total No of Submittal Required	169	286	CLN5/6 Stats comparison for submittals received up to project working week 31
Total No Right First Time	65	180	
Percentage Right First Time	38.46%	62.93%	

Figure 4. Right First-Time Percentage

The average right first time after implementation of LPS increased to 62.93%. The number of iterations post-first release has also reduced following the implication of the Mace LPS, resulting in significant improvements to the ratio of waste.

Work Package (Ratio of Right First Time to No of Iterations) of Submitter Type Issued	CLN5/6 Ratio of Waste
Civil Work Package	0.47
Steels Work Package	0.33
Mechanical Work Package	0.55
Electrical Work Package	0.53
Average / Trending	0.62

Figure 5. Ratio of Waste

The ratio of waste is trending at 0.62 for the current project compared to 1.17 for the previous phase. For the Civil Work Package, the percentage right first time has marginally reduced, and Ratio of Waste has marginally increased. However:

- The Civil Work Package was starting from a higher success ratio for the previous phase compared to the other Work Packages.
- The Civil Work Package was the first work package to employ the last planner approach, which required a learning curve period to bed in.
- The current project had a new design team and there is an element of trust building to be developed.

For the current project, the quantity of required Technical Submittals is trending at c.1,600 and projecting the ratio of waste would see c.1,600 number of Technical Submittals being presented c.2,592 times. Using LPS, we were able to measure and recognise variability and highlight trends to improve our productivity. If we did not introduce the Mace Last Planner to the submittal process, it would likely have seen the quantity of technical submittals being presented c.3,473 times – a delta of c.880.

An analysis of the time spent by the project team to prepare and review submittals for re-review equated to an average of 110 minutes of Project Time. The reduced number of re-submissions has resulted in a project saving of c.1,163 man-hours.



Figure 6. Submittal Time Calculation