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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, the US, Asia, and the Middle East, bringing world-class resources and the latest innovative technologies to every project. Our sector expertise spans many markets, including Biotechnology, Pharmaceutical, Medical Technologies, Oil and Gas, Advanced Technology, Food & Beverage, Energy, Science & Education. 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 1,800 people worldwide.

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Overview & Background to the Lean Initiative

This case study examines how process and value stream mapping can be utilised to optimise the hand-offs and quality checks required for an Off-Site Manufacturing (OSM) workflow. DPS Applied Technology Group (ATG) was engaged to design and develop the required structure to manage the OSM of a portion of a large client program. While the client wished to move to an OSM process, the changes required and the implications of the transition were not fully understood. DPS ATG worked closely with the client to determine the steps involved and the changes required to the client's existing systems and structures to implement the OSM process.

Lean Initiative Undertaken – Lean Thinking, Tools, Techniques

Whilst OSM is a move towards the implementation of a manufacturing-based system to improve construction productivity, the change in project infrastructures required to enable OSM can also be optimised by the implementation of Lean principles.

DPS utilised a number of key Lean techniques to enable the development of an OSM structure for a large client. This case study outlines the main principles considered in developing the program and the Lean thinking and techniques utilised for its optimisation.

Development of an OSM Framework

In the initial stages of developing an OSM framework, a number of considerations must be taken into account when setting up an OSM process for construction projects, including:

- Identification of OSM opportunities.
- Ability for trades to meet the OSM requirements.
- The establishment of a new framework for the project.
- Establishment of new standard operating procedures (SOPs).

It was determined that the DMAIC process could be utilised as the best methodology for the development of the OSM framework.

Define

While OSM can be applied in many stages across a project, one of the first determinations needs to be the establishment of what sections of the projects can be moved off-site, how much of the project can realistically be manufactured in a OSM environment, and what are the most value-adding OSM activities for the client.

It was decided to complete an OSM review with the client, coupled with a brainstorming session to determine the most value-add opportunities. A number of standard industry-recognised OSM definitions were drawn up, and the following categories were identified:

- Pre-Assembled Unit (PAU) – Unit fully designed and delivered to site for hook up.
- Supplier Package Unit (SPU) – An SPU designed and supplied by a supplier and delivered pre-assembled to the maximum extent possible. This often includes on-board automation allowing off-site FAT.
- Supplier Assembled Unit (SAU) – An SAU is a unit in which a supplier's normal scope of work is extended.
- Pre-Assembled Rack (PAR) – A PAR would be designed by the design contractor and comprise a pipe rack complete with piping, valves, cable trays, access walkways, tracing, insulation, and painting where applicable.
- Pre-Assembled Structure (PAS) – A complex structural assembly with a high weight-to-volume ratio and a large number of connections is designed, and it can often be more economically fabricated away from the project site.
- Rooms Module Unit (RMU) – An RMU is where rooms or suites of rooms are modularised as Pods. Typically, they should include all Mechanical & Electrical and Life Safety Systems that can be tied in at the site.

- Specialist Unit Design (SUDs) – The off-site fabrication of singular or specialist units for installation on site.
- Speciality Installation Designs (SIDs) – Repeatable units of multiple designs that can be fabricated elsewhere and provided to the trades-clients for installation.

Utilising these definitions as a guide, DPS completed a brainstorming session with the client and established a number of areas where OSM opportunities lay and the ease of implementation. A road-map of opportunities was identified (see Figure 1 blurred for confidentiality reasons).

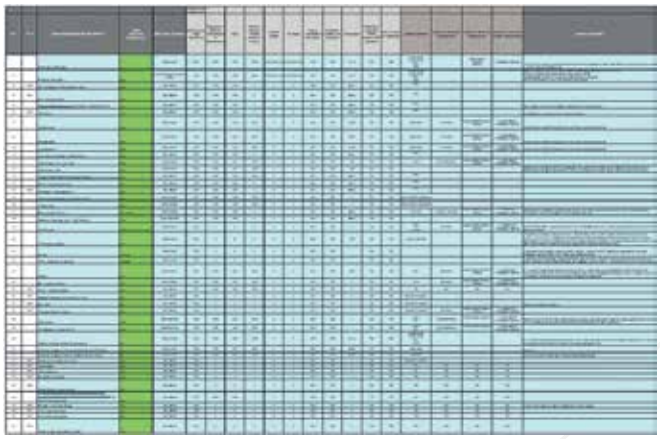

Figure 1. OSM Opportunities

The highest areas of return for the upcoming projects were identified as:

- Pre-Assembled Racks – A significant meterage of piping could be assembled off-site and installed en-masse in a matter of days.
- Pre-Assembled Culvert – For pipe transfer across the public roadway.
- MCC/CSR Rooms – These could be assembled internationally, shipped to Ireland, and road transferred to a local panel builder.
- Utility Panels – Pre-manufactured and consisted of assembled utility and service connections (piping and valves), sockets, and data.
- Mobile Vessels – Assembled off-site as complete skids, including panels.
- CIP Skids – Assembled off-site as complete skids, including panels.
- Waste Skid – Assembled off-site as a complete skid, including pumps, panels, and valves.
- LPHW Skid – Assembled off-site as a complete skid.

A current state analysis was carried out and it was determined that up to 22% of overhead could be transferred to OSM facilities and up to 42,000 hours of productivity could be gained. The first stage-gate of the framework development was passed as OSM was deemed to be viable and had an achievable return on investment.

Measure

The second stage-gate was to determine if the client's existing supply chain had the manufacturing capability to provide this service to the client. DPS compiled a CBA process to measure the capability of a number of trades within the local and international market. A total of 50 suppliers were measured against the CBA process, with five domestic trades and 15 international trades meeting or exceeding the criteria. DPS worked closely with the client's preferred suppliers to assess their capability and develop improvement plans for the preferred supplier listing.

Analyse

The next stage was to establish a new framework to allow the supply chain to understand how and where they fitted into the new OSM process. This was a significant change to the existing and established processes used historically on the projects. DPS developed a high-level value stream map (VSM) with the client and suppliers to determine the main hand-offs and pinch points.

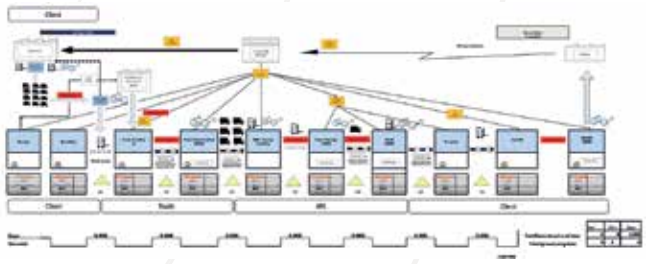

Figure 2. High-Level Value Stream Map

The VSM was utilised to establish the main owners, hand-overs, QAQC requirements, lead times, and integration points. This process was completed with all opportunities identified during the define stage and with all suppliers within the value chain.

The output of the VSM project was the generation of a RACI document to ensure clear and concise ownership of each hand-off with the corresponding deliverables and metric for success. A list of areas where new processes and procedures were required were identified by the team and summarised under the following headings:

- Schedule Integration.
- Design and BIM Optimisation.
- Materials Management.
- 4PL and Rigging.
- Trade Facility Optimisation.
- Storage Requirements.
- Transfer and Hand-offs.
- Site Installation.
- Quality Management.
- Performance Management.
- Continuous Improvement.

At this stage, teams were identified to determine if there were areas within the OSM VSM that could be improved.

Improve

The OSM implementation team utilised the VSM findings to determine areas for improvement for the overall process. All areas outlined in the Analyse phase required improvement projects to establish best known method (BKM) for OSM implementation. Sub-teams were formed to determine the best methods for the development of the OSM capability.

One example was the analysis of the existing design process to determine what items could be transferred into SIDs. The design

sub-team established a roadmap of items to focus on a developed process for the incremental development of design changes.

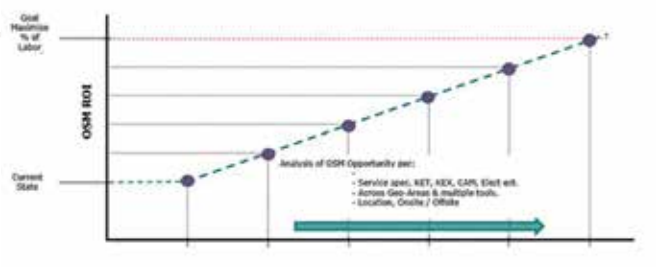

Figure 3. OSM M&E Progression Roadmap

Another example of a high-risk area identified by the process was the delivery and management of multiple specialist materials to the trades manufacturing facilities.

A sub-team was also formed to optimise the 4PL process and to establish the:

- Implementation of a singular 4PL process for management and transport of material.
- Optimisation of a singular QAQC process for traceability of issues.
- Implementation of a singular storage facility establishment of a Supermarket and JIT delivery system.

Similar improvement processes were established for all other key areas identified for the VSM process.

Control

DPS compiled a number of improvement standardisation workshops to ensure roles and responsibilities, deliverables, and work methods could be aligned between the trade capability, the client's

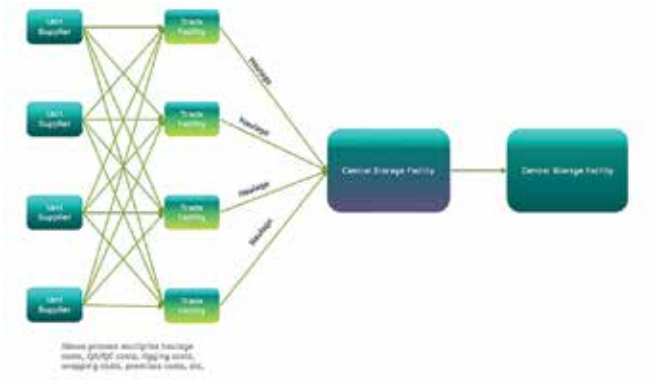

Figure 4. OSM Material Supermarket

requirements, and the project needs.

This resulted in the development of OSM-specific documentation consisting of:

- Standard Work Documentation: Containing detailed definition of the current best practices for performing an activity or process.
- Standard Operating Procedures: Step-by-step instructions compiled by the team to ensure the repeatability of the OSM module builds.
- Visual Management Processes: The implementation of a tracking system to indicate where in the process flow the OSM module was.
- Huddle Meetings: To track progress and correct issues as they arose.
- Kanban: For the delivery of the completed items to the site.

Approximately 150 documents were generated (not Lean in itself and DPS continues to work on improving this) for the establishment of the baseline requirements for the OSM framework.

Lean Initiative Improvements & Impact

Summary

In construction, the transfer of works to OSM is itself considered an implementation of Lean practices into the construction industry. While this is a step in the right direction, to improve construction productivity it must be comprehended that this is a significant change in some sectors of the construction industry.

What this case study has shown is that Lean processes and systems can be used in the development of an OSM framework for the client and their supply chain that can help with a transition from historical practices to more productive processes that can improve the overall delivery of projects.

The initial target on the project was to identify OSM opportunities to remove 22% of overhead from the project site that could be transferred from the project site to the OSM facilities with the corresponding productivity gain of up to 42,000 hours of productivity. The actual gains were 31% of OH moved to OSM activities while >60,000 hours of productivity were gained. As a consequence of developing the OSM framework for one project, DPS ATG was able to apply a similar process to a second project focusing on the OSM of a singular scope of work. This project is now in flow and results will be published in Q1 of 2022.

The significant Lean improvement and impact of this case study was the successful demonstration of Lean thinking and techniques in the establishment of a framework for change. While many Lean initiatives in construction focus on tactical solutions of issues occurring during the project, this case study showed how VSM could be utilised in a strategic development process to optimise a flow before the project begins.

The utilisation of the VSM process led to the identification of many bottlenecks within the new OSM supply chain. Supply chain logistics, QAQC checks, and the throughput of the Trade Manufacturing facilities needed to be added as KPIs to the delivery of the project. This also identified many areas where continuous improvements could be made. The manufacturing structure and capability of the supply chain now needed to be considered, the hand-offs between stakeholders needed to be optimised, the material supply chain needed to be reviewed, and the roles and responsibilities of each of the stakeholders agreed – and whilst the framework is established,

there is always room for ongoing improvement.

Next Steps

As projects become more complex, and time to market puts additional pressure on schedules, OSM will transition the construction industry closer and closer to a manufacturing industry. DPS believe that many opportunities exist within all sectors of construction to transition towards OSM and therefore reduce traditional site-based impacts such as weather and quality delays.

As an industry, the transition to OSM in construction will require the implementation of Lean processes and systems, and this can lay the foundation of a sustainable industry where modules can be manufactured and transferred globally from facilities in Ireland.

DPS is currently in the process of reviewing its OSM implementation framework to enable organisations to complete a current state analysis review to determine where they need to focus on and make changes before their next project starts. The key takeaway is that proactive planning utilising Lean thinking and techniques can lead to significant improvement on projects.

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