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Operating successfully for over 150 years, the bedrock of Royal BAM Group's success has always been an understanding of our clients' needs and a willingness to deliver innovative solutions that ensure cost savings and surpass environmental expectations. Operating across all construction sectors and throughout the complete project lifecycle, our principal activities are building contracting and civil engineering in the public, private, and PPP sectors. Other activities include facilities management, property development, and rail infrastructure.

We are a member operating company (OpCo) of Royal BAM Group of the Netherlands, a stock market listed PLC answerable for performance, which has a turnover of €8 Billion and employs approx. 23,000 people worldwide. At BAM, we are building the present while creating a sustainable future for all.

Author

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Overview & Background to the Lean Initiative

Miyamoto Musashi (1584–1645), was a swordsman, philosopher, strategist, writer, rōnin and is considered a Kensei – a sword-saint of Japan. In his final years he authored The Book of Five Rings, a book on close quarter combat that has become a foundation of Japanese strategic business and manufacturing thinking. In it, Musashi advises to ''… gather information from every possible source. Leave no stone unturned. Use spies, consultants, informants… Perceiving the enemy's position allows you to defeat it…''.

Today, we strive to learn from what we do and how we can continuously improve, and our enemy is a lack of timely information in the decision-making process. In August 2020, the Digital Construction Department of BAM Ireland attended its subsidiary Modular Homes Ireland (MHI) for a technical visit with a view to improving the execution of their digital processes. Since then, both companies have worked together to reduce waste and add value. Our journey began by mapping out the work process, and today we are digitally tracking that work to add greater value.

Lean Initiative Undertaken – Lean Thinking, Tools, Techniques

In August 2020, at an initial tour of the facility, BAM Ireland Digital Construction was introduced to MHI – a subsidiary of BAM Ireland – teams responsible for the design and production processes for the creation of steel panel modular houses and units. This was followed with a factory floor walk to get a better understanding of the entire production process, starting with the cold forming of the blank steel rolls into the modular panel wall frames, assembly of the units, and right up to the final wrapping of a completed module.

From this initial visit, it was clear that Digital Construction could bring value and remove waste from their processes through the application of Lean methodologies and the implementation of better digital technological practices.

Over the following visits, our first action was to complete a current state value steam map (VSM) so as to understand the entire production process, establish a benchmark value, and to use as a basis to build a recovery deployment plan.

VSM is a snapshot of how a process is currently executed, regardless of what the ideal or perceived process state may be – it reflects what is happening out in the real world. The VSM works to capture the entire span and duration of a process, and to identify within the process where value has been added or lost for the client. Undertaking this process gives visibility to waste or roadblocks in the overall production process and is created through direct process observations and forthright staff interviews to understand the pain points.

Over 3-4 visits we interviewed all the key personnel from each department and worked hard in the design office and on the production floor to understand the different task durations for the ''first of a kind (FOK)'' and ''many of a kind (MOK)'' events.

The MHI process begins with the client need which is translated via the design teams into a viable design. Once finalised, this FOK design is reviewed by the production team, and any lessons learned from the first production run are reapplied to the design, thus improving the outcomes for the following production units (MOKs).

Physical production starts with the cutting and forming of a flat roll of light gauge steel into a structural unit. These units are then moved to frame assembly where they are joined together to form the structural panels for the final unit being created. Panels are then combined to create the final modular structure, and these units move along the production line for slabbing, insulation, glazing 1st and 2nd fix, and so on, culminating in a fully-finished unit. Once all

quality checks have been completed, the unit is wrapped and made ready for delivery to the client's construction site.

After all the information had been gathered, a VSM was compiled and a finalised version was presented to the MHI management team for review and comment.
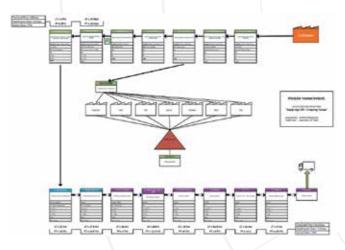

Figure 1. cVSM

The standout waste findings were:
- 20%+ non-value-add time within the internal design process.
- €100,000+ of product sitting idle on the production floor adding zero value.
- Panel team were over-producing in the range of 50%, leading to an oversupply of the assembly line and thus creating delays to production times.
- Overall production time was >4 times higher than the ideal state (albeit due to known reasons).

Responding to these findings, the digital construction team identified several opportunities for improvement:
- A digital method to track each unit through production and to dashboard the work in progress in near real-time, which would allow management to quickly identify and resolve any roadblocks in the production cycle and to better manage overall production time.
- The lack of a common data environment (CDE) was preventing the entire design team operating in a collaborative manner as well as the integration of stakeholders from design, production, and site installation on a single platform. This lack of a collaborative space was causing delays and miscommunication within the design process.

As not having enough timely information is the root cause to both of these findings, the digital team deployed two separate solutions. Both looked to reduce manual interaction with the process to address many of the 8 sources of waste identified within the opportunities.
- Unit Tracking – Digital Construction developed an in-house app to allow the different production managers track the start/stop work time for each unit. By using QR codes on each unit, the managers could open the app, scan the QR code to quickly identify the unit, and select a start/stop button to capture the time. This data was feeding a dashboard that management could access for near real-time information.
- CDE – Digital Construction deployed BIM360 from Autodesk to act as a common platform for the design process as well as the integration of the quality process, thus further enhancing the collaborative environment.

Figure 2. MHI App

Lean Initiative Improvements & Impact

Increasing Productivity and Sustainability Using Single Identity IoT

Current state mapping of MHI practices highlighted that substantial value could be added if production was accurately monitored and tracked in near real-time, thus providing MHI management with the information to take immediate action. However, the previous manual tracking and disconnected software solutions provided incomplete, inaccurate, or too outdated information to assess and action effectively. Additionally, they were finding that the in-house developed app was proving too cumbersome to implement efficiently.

MHI management recognised that there was room for improvement and executed extensive research looking for a single solution. The solution had to be flexible enough to identify units throughout their lifecycle, track processes activities around the assembly and installation, track the work completed, track equipment and stock in a production or construction environment by providing granular time-based activity, conditioning, and location data.

They found a new and innovative modular, multiprotocol, single-identity solution in Hiving Technology's "Hive OneID" product. The multiprotocol OneID building blocks enable cost-effective real-time data collection of all the components MHI set out to track Using NFC for close-range, Bluetooth for position tracking, and other radio frequency protocols for mid- and long-range tracking. The OneID has an active life of approximately three years and is passive through NFC for life, is modular, configurable, and can be equipped with sensors to suit requirements such as temperature, humidity, movement, tilt, and an accelerometer. This thus created a constant stream of granular data from connected manufacturing that construction operations used to learn and adapt to new or changing demands in near real-time.

Figure 3. Active Units & Readers

MHI deployed the OneID solution for tracking both modules and work. OneIDs transmit data on a regular configurable time interval, so installing readers in zones around the factory/sites and attaching the OneIDs to the module frames allowed tracking of the assembly and installation process until the finished module got installed on-site. In addition, the people and equipment involved in the build and installation are tracked and linked to the modules, which thus allows for the actual work to be heat-mapped in near real-time and provide data to optimise the value process.

Figure 4. Tracked Module

NFC on the module allows MHI to add value to the assembly process. For example, a building or quality process step can be acknowledged through a mobile app by simply tapping the mobile against the NFC, informing the user about the module's current status or proposing the next tasks to be completed – all specific to the users' role need. Additionally, the NFC stays active on the module for life, thus providing all the relevant lifecycle information for possible operational and circular recycling requirements.

Key to the OneID value is capturing the data in a granular format consisting of secure identification data and sensor values. The reader adds location and time information to the data that is captured. The reader infrastructure reads any OneID in range and updates the data seamlessly with BAM and other stakeholders.

This novel approach to capturing information has far-reaching consequences for how BAM approaches adding value to its digital construction. This OneID is a fundamentally simple approach that has its strength in being both modular and easily scalable. Implementing a single source system like this creates consistent and clean data, enables multiple stakeholder and system requirements, and seeds the data mining process of the BAM data lake to support the smart cities future.

Beyond the advantages to existing industrial construction practices, this solution can add value when applied to existing processes. When compared to the structured environment of a factory, the traditional construction site environment has an unstructured and often chaotic pace and flow. The challenge for the project management team is to get high-quality and timely information that will guide the decision-making process and therefore the optimisation of the value returned.

By implementing a single multifunctional modular solution, we can replace existing solutions to a single source platform. This alone addresses many sources of waste, including:

- Over-Production – We only create and collect the data we need on the item being tracked due to the modular nature of the solution.
- Over-Processing – With a modular solution that runs on a single platform, there is no need to translate the data into a common format. In addition, the fundamental nature of the data allows for multi-use analytics beyond the original need for the data.
- Inventory – A scalable modular solution can address the need to have multiple products from different vendors as this solution can replace them. For example, the same thermo module can track concrete curing or storage temperatures for modular bathrooms.

On a highly-dynamic construction site, the ability to track the resources, plant, and materials for each work task in near real-time will enable better daily management, provide metrics to support continuous improvement, and generate data to verify the value-add to both the client and the stakeholders.