Rethinking Lean with Digital Manufacturing

Lean Manufacturing processes have revolutionized the way that many leading enterprises identify and eliminate waste in complex manufacturing environments, thus streamlining processes and reducing cycle times. Sixty-three percent (63%) of companies Aberdeen Group surveyed for the Lean Product Development Benchmark Report and evaluated as top performers (the Best-in-Class) report having Lean Manufacturing deployed for over two years. This has provided these companies with considerable competitive advantages, enabling them to hit cost and revenue targets for over 80% of their products. These Best-in-Class companies support Lean Manufacturing with a concurrent design approach by which they simultaneously develop products and production processes. To support this approach, they are implementing advanced Digital Manufacturing (DM) technologies to develop and deploy optimal manufacturing processes and simulate manufacturing processes to proactively validate product and production designs. As a result, these companies are aligning the requirements of the manufacturing process with the design of the product itself. They are improving manufacturing efficiency and preempting the need to revise completed designs to meet manufacturing constraints.

Supporting the Lean Enterprise

Lean Manufacturing has a lot of appeal in a market where global and domestic competition compels companies to pursue more efficient processes and increased throughput on tighter budgets. Companies Aberdeen Group benchmarked as the Best-in-Class in Lean implementation for the May, 2007 Lean Product Development Benchmark Report demonstrated a significant competitive advantage over their peers (Figure 1). On average, the Best-in-Class were able to hit launch revenue targets 83% of the time and product cost targets 87% of the time. This is a significant lead over the Industry Average which, on average, hits these targets less than 60% of the time. Moreover, Best-in-Class companies are 1.6 times as likely as the Industry Average to have Lean Manufacturing principles implemented for more than two years.

Recommendations for Action

- Implement Lean Manufacturing to improve production efficiency
- Implement concurrent design to proactively develop Lean Manufacturing processes
- Leverage Digital Manufacturing (DM) to support concurrent design and Lean Manufacturing improvements
Aberdeen Group research has shown that Lean can reduce costs and streamline processes in the manufacturing industry. However, findings from Aberdeen Group’s May, 2007 *Lean Scheduling and Execution* benchmark report uncovered that 34% of Best-in-Class performers cite “using manufacturing as a competitive advantage” as a motivating factor when implementing Lean concepts. This was indicated more often than the demand for shorter lead times (32%) and the need to compensate for the increasing complexity of manufacturing processes (18%). With Lean showing proven value to the manufacturing organization, it is now being implemented by leading companies not simply to reduce costs but to differentiate the enterprise within the market.

Even with the best implementation programs, however, companies continue to face roadblocks to lean the enterprise. Even where manufacturing processes have been optimized, organizations still face unnecessary waste and costs resulting from poor integration between engineering and manufacturing. This results in decreased efficiency, or wasted time and effort, if inefficient production processes result in designs that must be sent back for revision when they cannot be effectively produced in the plant. To resolve this problem, companies are expanding Lean to cover areas and departments that are outside of the manufacturing plant to better streamline their organizations.

Research from Aberdeen Group’s May 2007 *Lean Product Development Benchmark Report*, in particular, found that Best-in-Class companies are 69% more likely than Laggards to have extended Lean concepts across the product lifecycle (Figure 2). In particular, the Best-in-Class are 39% more likely than Industry Average performers (71% versus 51%) to implement Lean in the transfer of a design from product development to manufacturing. As a result, these companies are able to pursue Lean Manufacturing by an anticipatory approach, aligning the requirements of the

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**Figure 1: Ability to Hit Product Profitability Targets**

![Figure 1: Ability to Hit Product Profitability Targets](image)

Source: Aberdeen Group, May 2007

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**Competitive Framework Key**

The Aberdeen Competitive Framework defines enterprises as falling into one of the three following levels of practices and performance:

- **Best-in-Class (20%)** — practices that are the best currently being employed and significantly superior to the industry norm
- **Industry norm (50%)** — practices that represent the average or norm
- **Laggards (30%)** — practices that are significantly behind the average of the industry
manufacturing process with the design of the product itself and preempting the need to revise completed designs to meet manufacturing constraints.

**Figure 2: Where Lean is Implemented in the Organization**

![Bar chart showing percentage of companies implementing Lean in different stages of the product life cycle.](chart.png)

Source: Aberdeen Group, May 2007

**Pursuing Concurrent Design**

Whatever the organization or the process under consideration, Lean philosophy requires measuring the standard performance of a task with an eye to continually improve future performance. This has resulted in a greater, company-wide scrutiny on how to streamline processes from the beginning. What this means for the design process is a vision that doesn't end at the design's transfer to manufacturing, but takes a fuller consideration of all aspects of production. The Best-in-Class are not only more likely to have deployed Lean in design and release to manufacturing cycles, they are two thirds more likely to have already been doing so for more than two years. By streamlining processes and validating design, these companies are anticipating problems in the earliest stages to reduce costs and avoid delays ahead of the manufacturing process.

Lean’s central value is always the reduction of waste. Thus, an important metric deployed in Lean initiatives is a measurement of the percentage of effort spent on “value-added” versus “non value-added” activities. In order to accomplish this, companies have adopted a method known as concurrent design. Concurrent design is a strategy by which a company simultaneously co-develops the product along with its manufacturing process. Too frequently, companies follow a serial design approach, where the manufacturing processes are developed only after the initial design of the product is completed. The major drawback of this process is the inability to anticipate whether or not a product can be physically constructed within the plant until after the entire design is completed. As a result, designs have to be returned to engineering for modifications to allow construction within the limitations of the company’s manufacturing capabilities.
Concurrent design, by contrast, is an approach that takes the manufacturing process into consideration during the product design phase. By designing the product with an eye to the constraints of production, companies are able to avoid the costly delays of unnecessary revision. Manufacturing issues that are discovered in the design process are issues that can be addressed before they arise. At the same time, plant layouts and equipment that often can’t be altered once the manufacturing process is begun can be determined in advance while changes can still be made. As such, concurrent design allows manufacturers to better forecast and analyze costs in the design phase. Aberdeen Group’s research found that Best-in-Class performers are 43% more likely than Industry Average performers to have implemented concurrent design practices as a Lean strategy (Figure 3).

**Figure 3: The Best-in-Class are 43% More Likely to Implement Concurrent Design**

A concurrent design approach permits companies to validate manufacturability and develop production processes early in the product design cycle by coordinating the knowledge of product engineers, manufacturing engineers, and manufacturing personnel in a collaborative environment. The result is a design that is completed more rapidly and efficiently for fast production ramp-ups, increased throughput, and an overall faster time to market. At the same time, concurrent design enables companies to develop and communicate better manufacturing processes preemptively. In effect, concurrent design means reducing the occurrence of late Engineering Change Orders (ECOs) without sacrificing inefficiency or costs in manufacturing which, in turn, results in a more profitable product.

**The Advantages of Digital Manufacturing in Lean Manufacturing**

Digital manufacturing technology offers companies the opportunity to provide engineers with the tools to plan, design, simulate, and communicate manufacturing processes through a suite of software solutions that support manufacturing, engineering, and process design. DM enables the user to produce digital models of products in virtual plants in order to perfect manufacturing processes before the physical plant investments have been made. This environment provides for everything from detailed work...
instructions and program code for automated plant equipment, to validation of the overall throughput with material flow simulation. All of this can be developed in parallel with the product design, allowing manufacturers to ramp up production of new products more rapidly, with higher quality, and at a lower cost. In particular, digital manufacturing is a solution that Aberdeen’s research found to be in use by Best-in-Class performers 56% more often than the Industry Average (Figure 4).

**Figure 4: The Best-in-Class are 56% More Likely to Deploy DM**

The Best-in-Class are more likely to utilize digital manufacturing, but what does it entail? In the simplest terms, a digital manufacturing enabled approach involves the adoption of new business processes; design methodologies, organizational approaches, and software tools to pursue concurrent design and develop optimal manufacturing processes. Digital manufacturing technologies reduce the need for physical prototypes and mockups for facilities, production lines, and fixtures. DM concepts work at the detailed level as well, allowing tooling, weld paths, ergonomic considerations, and other critical details to be designed and analyzed in advance. As a result, the technology provides manufacturing engineers with more effective and cost-efficient means to prove a product can be manufactured and assembled before making significant investments. Digital manufacturing provides tools and techniques to help predict and analyze the need and effectiveness of adjustments to the line. By applying these tools, manufacturing and process engineers can identify bottlenecks, spot inefficiencies, and develop corrective action – thus eliminating waste and proactively leaning out manufacturing.

**Visualizing Production**

Once a product is in production and the line has been tooled up, the ability to implement changes to improve processes and eliminate waste becomes limited. Visualizing how a product will be assembled in the plant, particularly in complex product manufacturing, is a difficult task for most engineers. It is just as important to design the automated production lines, workstations, and operations of manufacturing with the same efficiency in mind. While concurrent design mandates the simultaneous design of product and process, many manufacturing processes today have been automated through the use of intelligent robotics, machining, inspection, and material handling.
equipment. The resulting interplay between the parts being assembled and the fixtures, tooling, robots, and operators of manufacturing is by nature a three dimensional problem.

Simulation can play a large role in streamlining the work involved in accounting for all of these components. DM provides the engineer with the capability to program and simulate the use of automated manufacturing operations in context with the parts they are producing, which allows the process engineer to literally see the process in action. As a result, digital manufacturing provides engineers with the ability to simulate manufacturing processes before the plant or production line may even exist, extending visualization beyond product innovation and into the design of the manufacturing operation.

**Digital Manufacturing Broadens Virtual Prototypes**

Aberdeen Group research shows that manufacturers have realized the business value of employing virtual simulation in the design process. To communicate complex designs, product engineers have turned to visual design and communication tools to translate the product in their imagination into a digital representation. Once digitized, the design can be shared, communicated, and collaborated upon electronically with others. Today’s Computer Aided Design (CAD) systems reduce the burden on verbal and written communication, allowing product designs to transcend differences in location, time, and even language.

As CAD tools have become more powerful and incorporated 3D modeling, communication has improved dramatically. Even complex products with thousands of components can now be modeled accurately and communicated effectively to other engineers, customers, suppliers, and manufacturing personnel. As 3D simulation has advanced, it has allowed manufacturers to test designs in a virtual environment, which eliminates production of potentially expensive prototypes. Virtual prototypes enable companies to replace the expense and time of physical prototyping with rapidly produced and cost-effective digital models in virtual environments. In fact, Aberdeen research found that 78% of the Best-in-Class currently verify designs in simulation, as do 68% of Industry Average companies (Figure 5).

**Figure 5: Verifying Designs with Simulation**

<table>
<thead>
<tr>
<th>Designs Verified Through Simulation</th>
<th>Best-in-Class</th>
<th>Average</th>
<th>Laggard</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>78%</td>
<td>68%</td>
<td>45%</td>
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“Digital manufacturing helps us lower set up times and reduce quality checks, allowing us to lean out our machining and forming processes.”

~Project Manager, Discrete Manufacturer
Beyond simply validating the product design, however, engineers can validate that the product can be manufactured and assembled both effectively and efficiently. Digital manufacturing technologies are being employed to create a virtual analysis of production. As a result, DM provides manufacturers with the opportunity to leverage the power of the digital product combined with the power of digital processes and resources to create a Lean “digital factory” environment.

For complex products, simulation of the assembly and disassembly processes is necessary to understand whether or not the product can be produced and maintained efficiently. When new equipment is deployed, manufacturers must get it working quickly to start generating revenue, while for existing equipment, manufacturers must reduce the need for downtime. Downtime is a waste that Lean organizations cannot afford. Potential clashes and interferences can be found in virtual simulations that typically are not found in the design cycle when production sequences have not yet been defined. It is possible, for example, for parts to fit perfectly in a digital mockup that only analyzes the final fit, and not the collisions that occur during the assembly process itself. Sometimes, clashes are not even visible from the outside, which makes the problem very difficult to detect without appropriate simulation or expensive prototypes and mockups.

By simulating production of virtual products in virtual plants early in the product design process, designs for the products themselves can be enhanced to make manufacturing and assembly Lean and efficient. When engineers become able to identify a potential problem in advance, they can change the layout to make it easier for worker to assemble parts and streamline the work process. More advanced tools can be deployed to automatically flag potential problems through analysis of the simulation. This approach allows companies to evaluate multiple plant and process designs and to determine the best approach to manufacturing the product before even investing in a prototype and with a significant reduction in engineering changes after deployment. Understanding problems earlier in the process eliminates mistakes in a virtual environment where they don’t cost anything—leading to the development of production facilities and processes in a much faster, more efficient, cost effective and error free way.

**Beating the Learning Curve**

DM moves many of the choices about how a product will be produced forward in time, elevating the importance of manufacturing processes in relation to the lifecycle of a product. One of the benefits of making as many of these decisions in the virtual environment as possible is that it allows manufacturing engineers to evaluate multiple, potentially radically different, scenarios without the expense of physical equipment or mockups. When put into practice, simulation can lead to better innovation. Where a misstep in the physical environment would be a cost the manufacturer for years to come in terms of retrofit, redesign, or inefficient manufacturing, the only penalty for being wrong in a virtual environment is a simple learning exercise. This allows manufacturers to explore innovative approaches that could not be seriously considered under the time and cost constraints of
physical testing. The more innovative path (without the ability to visualize and prove the potential results) would remain undiscovered or appear too risky for the business—and for the individuals involved.

Making changes in a digital factory environment means that the real-world factory can stay online and generate a return for the business. Changes to products impact processes and changes to processes impact resources. More importantly, in an era where components are often manufactured remotely, ensuring that products are produced according to design requires that operators be able to learn the processes in an intuitive way. Digital Manufacturing, in addition to optimizing existing processes, also makes it possible to start the learning curve early for new processes. By simulating and analyzing the manufacturing processes and resources in advance, the first time the product is produced physically can be a more refined, optimized iteration of the process. In essence, digital manufacturing allows engineers to tune the line in a virtual environment—increasing early efficiencies to levels unachievable by deploying and continuously improving physical deployments that are constrained by change.

**Required Actions**

Lean Manufacturing is a philosophy with a proven business benefit. The companies that support Lean initiatives see the opportunity to increase the throughput of their facilities even as production itself becomes more costly and complex. Specifically, supporting Lean Manufacturing means expanding Lean concepts earlier in the product lifecycle and pursuing a concurrent design approach to develop product designs, plants, and processes simultaneously. Companies should implement concurrent design by leveraging digital manufacturing solutions. These are the technologies that enable companies to proactively Lean out the enterprise by constructing digital models of products in virtual environments before the physical plant investments have been made, driving efficiency, reducing waste, and improving overall product profitability. For more information on this or other research topics, please visit [www.aberdeen.com](http://www.aberdeen.com).