Research Brief

Aberdeen Group
A Harte-Hanks Company

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Improving Productivity with Digital Manufacturing and Planning

Improved productivity is a core goal in any aspect of an enterprise, particularly under strained economic conditions. It's a goal that takes on considerably more weight in manufacturing planning processes. Waste and delays here can have direct consequences on a company's productivity which affects many things including the ability to meet targeted product launches. Many companies find that their ability to achieve this goal is hampered by obstacles resulting from limited facility resources and variations in employee knowledge and skill, among other issues.

How do manufacturers overcome these challenges? Aberdeen's September 2008 study on *The Computer Integrated Manufacturing View* isolated the manufacturers that have reached the highest levels of efficiency, and identified the practices these leaders adopted to achieve this goal. These practices are organized around six key areas where the Best-in-Class focus their attention. Perhaps most importantly, this focus doesn't just help these companies boost the productivity of production planning, but of the production process as well.

Research Brief

Aberdeen's Research Briefs provide a detailed exploration of a key finding from a primary research study, including key performance indicators, Best-in-Class insight, and vendor insight.

Shrinking Schedules and Cost Concerns are Top of Mind When Improving Productivity

What drives manufacturing planning organizations to focus on improving productivity? To find an answer to this question Aberdeen researched the top pressures on these organizations, asking study participants to identify the top pressures driving them to improve the manufacturing planning process (Table 1).

"Taking into consideration what we had in place two years ago, the recent changes we've made in organized planning has provided us with considerable benefits. It's allowed approximately a 160% increase in production capabilities, as well as an extreme cutback in standard lead times."

~ Jack Leach, General Manager, TriState Machine LLC

Table 1: Top Five Pressures Driving Manufacturing Planning Improvement

Pressures	Response
Shortened development schedules	49%
Increasing cost of raw materials	35%
Market demand for increased product quality / reliability	31%
Decreasing manufacturing budget	26%
Increasing cost of energy / operating costs	23%

Source: Aberdeen Group, September 2008

Not surprisingly, the top pressure cited by survey respondents is shortened development schedules. Very clearly the improvements these manufacturers are making enable them to do things faster and become more productive.

When viewed in conjunction with material and resource cost, budget, and product quality related issues, the theme that emerges speaks to the need to optimize resources for production while streamlining the planning process.

Obstacles Preventing Productivity Improvements

Lasting and progressive improvements in manufacturing planning productivity are difficult to achieve. Doing so requires successfully addressing a large number of barriers. Table 2 highlights the top five most cited challenges reported by participants in Aberdeen Group's *The Computer Integrated Manufacturing View* study.

Table 2: Top Five Challenges of Improving Manufacturing Planning

Challenges	Response
Employee skills and knowledge are varied	38%
Engineering design data changes until release	25%
Engineering designs parts without regard for manufacturability or assembly	24%
Product complexity is increasing	22%
Facilities resources are fixed	17%

Source: Aberdeen Group, September 2008

The top challenge manufacturers report is the varied level of skill and knowledge among employees. This challenge can often result from the loss of existing employees due to retirement, workforce reduction, or other factors that cause them to leave the company. The globalization of manufacturing processes is also a major contributor to this challenge. As companies expand their businesses to international markets or work with new global partners, they are likely to encounter disparate skill sets. New global locations may lack the expertise of seasoned experts with years of experience, or they may simply be unfamiliar with the standard practices the manufacturer uses. In any of these cases, the challenge before manufacturers is to find ways to capture and disseminate knowledge in a way that creates a standard level of expertise, regardless of who produces a part.

Changing engineering data also makes it difficult to plan for manufacturing. Similarly, a lack of visibility into manufacturability issues creates problems that have consequences for productivity later on. This often means it takes longer than necessary to produce a design, creating further delays before revenues can be realized. Even worse, it can mean that the part can't be produced as designed. The challenge for companies is to find ways to bring engineering and manufacturing together to bridge communication gaps and overcome these delays.

Finally, increasing product complexity coupled with fixed facility resources generate additional problems that must be overcome. In particular, it can be difficult to work around fixed resources. Optimizing productivity comes down to finding ways to maximize the use of existing resources without incurring additional costs or investing in new equipment. Once the facility becomes operational, it becomes extremely costly to make any adjustments that would lead to better productivity. The problem for manufacturers is to find ways to better utilize resources while there is still flexibility to make changes.

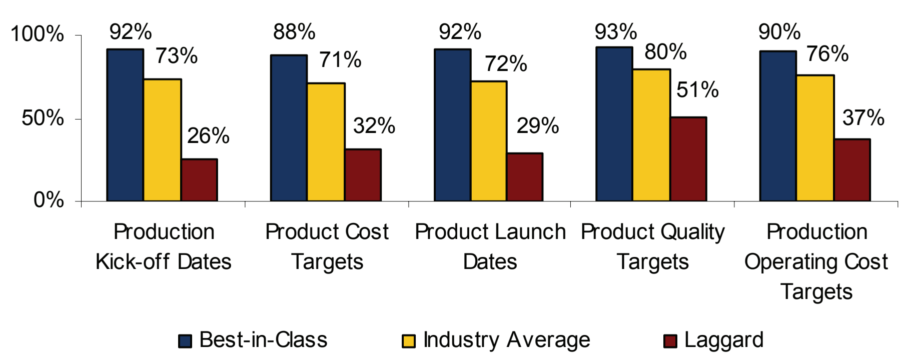
Aberdeen Analysis

The critical factors preventing manufacturers from improving productivity can be summarized as three key questions that must be answered to overcome the top challenges of improving manufacturing planning and production:

- How do I coordinate engineering and manufacturing planning needs?
- How do I maximize the utilization of existing facility resources?
- How do I overcome varying skill sets and knowledge bases?

To help manufacturers find the answers to these questions, Aberdeen's September 2008 *The Computer Integrated Manufacturing View* study surveyed over 240 companies regarding the steps they take to improve their manufacturing processes. Participants were benchmarked according to five key performance criteria. Using these metrics, Aberdeen categorized respondents into the top 20% (Best-in-Class), the middle 50% (Industry Average) and the bottom 30% (Laggard) of performers. Figure 1 displays the performance gaps that define Best-in-Class and the Industry Average.

Figure 1: The Maturity Class Framework



Source: Aberdeen Group, September 2008

Best-in-Class companies differentiate themselves by successfully addressing manufacturing planning challenges in ways that lead to greater productivity during production. Given the high priority of shortening development cycles, it's important to highlight the following:

- The Best-in-Class meet production kick-off dates 26% more often than the Industry Average and 3.5 times as often as Laggards
- The Best-in-Class report on average 38% fewer days between design release and manufacturing production than the Industry Average, and they reach manufacturing production 47% faster than Laggards

What is critical here is not that the Best-in-Class meet kick-off dates more often simply because they start the process earlier than their competitors. In fact, the opposite is the case. Aberdeen's research indicates that it is because they have the processes and technologies in place that enable a higher level of productivity. These capabilities are discussed in the following section.

The benefits the Best-in-Class enjoy with digital manufacturing manifest themselves in a number of ways, particularly in helping these manufacturers reduce the number of Engineering Change Orders (ECOs) that are made after release to manufacturing. ECOs impede the manufacturing production process in a number of ways. On one hand, they cause delays as manufacturers determine how to implement a change. Additional delays and costs are incurred by the rework required to execute the change and as a result of scrapped work. The Best-in-Class report 64% fewer ECOs after release to manufacturing than the Industry Average.

Not surprisingly, the Best-in-Class are also 2.2-times more likely than the Industry Average to be satisfied with their ability to accommodate ECOs with minimal impact to the manufacturing work that has already been completed. Fewer ECOs and greater productivity, also lead to lower cost, which is reflected in the ability of the Best-in-Class to keep production operating costs lower; targets these manufacturers meet 18% more often than the Industry Average and 2.4-times as often as Laggards. Improved productivity also leads to faster time to volume, which the Best-in-Class also report. When compared to the Industry Average, they are able to reach time to volume by 41% faster for machined piece parts.

Pillars of Best-in-Class Performance

So, what do these companies do differently to be more successful than their peers? Aberdeen identified six key areas where these leaders focus their attention:

- The development and management of the mBOM
- Engineering / manufacturing collaboration
- Facility and resource planning
- Validating work instructions
- Robotics automation planning

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- Learning from planning and enabling reuse

The processes the Best-in-Class have in place in each of these areas enable them to improve the efficiency of the planning process. This has an impact on the productivity of the production process as well. Improved production planning enables the Best-in-Class not only begin production sooner, but they start with an optimized production process that ensures products are released to the market on time (Figure 1).

Development and Management of the Manufacturing Bill of Materials

In engineering, the Bill of Materials (eBOM) is generally organized according to how the product was designed. The manufacturing organization likewise needs a manufacturing BOM (mBOM) that represents how they will produce the product. Unfortunately, the BOM they receive from engineering is often ill-suited for their needs.

The Best-in-Class begin by creating the mBOM by reordering the eBOM (Table 3). In fact, the Best-in-Class take this step seriously enough that they are nearly twice as likely as Laggards to dedicate a specific role to create and manage the mBOM. It is also significant that all of this is done within a Product Data Management (PDM) system. This directly addresses the difficulty of keeping up with changing engineering data, one of the top reported challenges, by ensuring that those changes are propagated automatically to the mBOM. Automatic propagation avoids time lost in making these changes manually. Moreover, it helps organizations avoid wasting time correcting the errors that occur when the mBOM doesn't reflect the eBOM.

Table 3: Leveraging the mBOM

	Best-in-Class	Industry Average	Laggard
Process	mBOM created by reordering the eBOM to represent the sequence of production		
	65%	**49%**	**46%**
Organization	Specific, dedicated role employed to create and manage mBOMs		
	40%	**33%**	**21%**
Enablers	▪ **50%** Engineering and manufacturing systems integrated to synchronize the mBOM ▪ **55%** mBOM created in Product Data Management (PDM) system ▪ **53%** Manage mBOM within PDM system	▪ **39%** Engineering and manufacturing systems integrated to synchronize the mBOM ▪ **45%** mBOM created in Product Data Management (PDM) system ▪ **49%** Manage mBOM within PDM system	▪ **32%** Engineering and manufacturing systems integrated to synchronize the mBOM ▪ **39%** mBOM created in Product Data Management (PDM) system ▪ **43%** Manage mBOM within PDM system

Source: Aberdeen Group, November 2007

Keeping this information within a PDM system effectively means that there is a single source of information. The time saved by automatically reusing engineering information in the mBOM is only one of the ways that this single source helps the Best-in-Class improve productivity and save time. It also:

- Reduces the time that's spent searching for latest product information
- Eliminates the time required to propagate changes from engineering to manufacturing BOMs
- Reduces the chance of errors that consume time to correct
- Prevents sending incorrect information to suppliers that would cause even further delays
- Eliminates the time required to propagate data to bills of processes and process documentation

Engineering / Manufacturing Collaboration

The Best-in-Class further improve collaboration between the engineering and manufacturing planning organizations by putting the processes in place to ensure that manufacturability is considered during the design phase and production is optimized (Table 4). This includes verification of manufacturability during the design process, validation that materials are optimal for manufacturability, and the impact that engineering changes will have on the production schedule. By putting these checks in place they are also addressing the challenge of engineering's lack of visibility for manufacturability.

Table 4: Design for Manufacturability and Assembly

		Best-in-Class	Industry Average	Laggard
Process	Check for manufacturability during the design process	**82%**	**67%**	**63%**
Process	Evaluate different materials to determine optimal choice for manufacturability	**71%**	**54%**	**51%**
Process	Evaluate effects of engineering change on production schedule	**65%**	**54%**	**43%**
Knowledge Management	Engineering has access to guidelines and best practices to optimize manufacturability	**71%**	**54%**	**49%**
Knowledge Management	Manufacturing has access to recommended processing conditions / machining information based on simulation results	**54%**	**38%**	**29%**

Source: Aberdeen Group, September 2008

The Best-in-Class also capture engineering and manufacturing knowledge in a way that improves the productivity of both organizations. For engineering, this means leveraging manufacturing knowledge with guidelines and best practices for how to optimize designs for manufacturability that will lead to greater productivity during manufacturing. For production, this means having access to recommended processing conditions and machining information based on simulation results.

Making this information available is an important step to addressing the challenge created by disparities in employee skills and knowledge. It also helps streamline processes to improve productivity. Capturing manufacturing knowledge and making it available to engineers means not just that manufacturability is considered during design, but that steps are taken to optimize the part for faster production, ultimately improving throughput. Providing manufacturing engineers with the insights into the product gained through simulation promotes a similar result. They do not need to waste time determining optimal production parameters.

Facility and Resource Planning

After ensuring that engineering and manufacturing preparation processes are coordinated, the Best-in-Class take steps to improve the utilization of facility resources (Table 5). In this respect, the key characteristics of the Best-in-Class are allocation of machine tool resources and layout of facilities *prior to design release* and the use of digital tools including 3D layouts, simulation, and plant capacity analysis to do so.

Table 5: Facility and Resource Planning

	Best-in-Class	Industry Average	Laggard
Process	Allocate machine tool resources prior to design release		
	69%	**33%**	**29%**
	Begin to layout the facility prior to design release		
	65%	**63%**	**32%**
	Facility materials flow is simulated to verify throughput		
	35%	**26%**	**12%**
Knowledge Management	Management visibility to capital equipment usage		
	73%	**51%**	**40%**
Enablers	▪ **71%** Plant capability analysis ▪ **68%** Manufacturing process planning tools ▪ **30%** Workcell equipment & machinery designed in 3D ▪ **20%** Facilities laid out in 3D	▪ **59%** Plant capability analysis ▪ **58%** Manufacturing process planning tools ▪ **26%** Workcell equipment and machinery designed in 3D ▪ **20%** Facilities laid out in 3D	▪ **49%** Plant capability analysis ▪ **51%** Manufacturing process planning tools ▪ **11%** Workcell equipment and machinery designed in 3D ▪ **7%** Facilities laid out in 3D

Source: Aberdeen Group, November 2007 and September 2008

As before, these steps don't just spur productivity gains in manufacturing planning, but in the production process as well. How? For example, the use of digital tools to layout facilities in 3D and simulate the flow of materials through the facility don't just help streamline planning; they empower manufacturing engineering to make better decisions. The insights gained from accurate representations of facilities in three dimensions make it easier to identify and address facility configuration issues. Not only does this help to speed manufacturing ramp-up, it also helps improve how facilities are utilized to optimize throughput, even before production has started. This directly addresses the top challenge of fixed facility resources. The ability to plan in a digital environment means different scenarios can be evaluated to determine the optimal one that will lead to the greatest productivity well before any investment has been made in establishing production lines.

The Best-in-Class also differentiate themselves by providing management visibility to capital equipment usage. In fact, they are 83% more likely than Laggards to do so. Providing management with this kind of visibility enables them to make adjustments to its usage and ensure they are getting the most out of their equipment investments. However, ensuring that productivity is optimized requires that these decision-makers have access to accurate, up-to-date information. Here again, a single source of information helps ensure that management doesn't just have visibility into the usage of equipment, but the correct visibility.

"We did a recent addition to our manufacturing facility, where simulation and planning were crucial. Using a 3D model facility and equipment helped with planning our plant expansion. A picture is worth a thousand words. 3D visualization gives us in-depth knowledge of what we're looking at. You can rotate it around, scale it so that it makes more sense."

~ Jon Bangs
Project Engineer
Bauer Compressors, Inc.

Validating Work Instructions

Of course, facility resources aren't limited to the equipment on the floor. They also include the manufacturing staff and operators who run the equipment. The next step after laying out the facility is creating the instructions that direct operators on what must be done to complete each operation in the manufacturing process. Core capabilities of the Best-in-Class include developing work instructions concurrently with product design and process, formally identifying best practices for work instructions, and centrally managing these instructions (Table 6).

As in other areas, these practices enhance the productivity of the manufacturing process in addition to the planning process.

Table 6: Facility and Resource Planning

	Best-in-Class	Industry Average	Laggard
Process	Work instructions developed concurrently with product design		
	67%	**45%**	**37%**
Knowledge Management	Work instructions are centrally managed and controlled		
	85%	**67%**	**68%**
	Best practices for work instructions are formally identified		
	70%	**53%**	**49%**
Enablers	▪ **44%** Assembly instructions created leveraging 3D CAD model ▪ **41%** Work instructions created using 3D CAD model ▪ **22%** Assembly instructions animated in 3D	▪ **16%** Assembly instructions created leveraging 3D CAD model ▪ **24%** Work instructions created using 3D CAD model ▪ **3%** Assembly instructions animated in 3D	▪ **20%** Assembly instructions created leveraging 3D CAD model ▪ **14%** Work instructions created using 3D CAD model ▪ **0%** Assembly instructions animated in 3D

Source: Aberdeen Group, November 2007

As with the use of PDM to centrally manage the eBOM, process and mBOM data, centrally managing design data ensures that there is a single source of knowledge. This ensures that when assembly and machining instructions are developed simultaneously with product development, changes to the design are propagated to the instructions. Starting this work earlier and ensuring its accuracy reduces the time required for manufacturing planning once the design is complete. As such, it improves productivity by accelerating the manufacturing planning stage so that parts can be produced sooner.

The Best-in-Class also leverage 3D CAD to create assembly and work instructions. This saves time in the planning phase by automating this process. At the same time, communicating instructions through direct 3D representations of the product means that the instructions are easier to understand which is especially important in a global environment with language barriers. The Best-in-Class enhance this aspect of work instructions by creating animations of assembly. Since these animations are created using the 3D design asset, they have the added benefit of validating the accuracy of instructions and confirming that safety requirements are met. This has an impact on manufacturing productivity as well and further addresses obstacles stemming from disparities in employee knowledge and skills through a more readily consumed method of communication.

"A lot of people use 3D for design because it's easier to quantify design processes, but once the design is thrown over the wall somebody has to physically build it. When designing complex systems, it is easier for people to understand what they're assembling if you have a 3D model than if not. That is one of the biggest reasons we went that route."

~ Ed Danzer
Chief Technical Officer
Danzco, Inc.

Robotics Automation Planning

Another area where the Best-in-Class save time with their manufacturing deployment is in the creation of robotic programming. Robotic automation has been pursued for some time to improve the productivity of manufacturing operations and helps to address the challenge of increased part complexity. The Best-in-Class build on the investments they make in robotics by the steps they take in the manufacturing preparation stage (Table 7).

The Best-in-Class simplify the process through offline programming of autonomous machinery and by verifying programs using simulation. This means that production delays due to debugging and correcting programs are minimized because the routines can be validated prior to production, even for highly complex automated cells.

Table 7: Improving Robotics Planning Efficiency

	Best-in-Class	Industry Average	Laggard
Process	Autonomous machinery is programmed offline		
	76%	**53%**	**39%**
	Robotic programming routines reused on new jobs		
	38%	**20%**	**3%**
Enablers	▪ **20%** Robotic programs verified using simulation	▪ **9%** Robotic programs verified using simulation	▪ **9%** Robotic programs verified using simulation

Source: Aberdeen Group, November 2007 and September 2008

Learning from Planning and Enabling Reuse

A recurring theme in the practices adopted by the Best-in-Class up until this point has been the importance of a central source of information. Table 8 indicates just how deep that goes, with the Best-in-Class centrally capturing and storing workcell designs, machine tool usage, and control plans for facility usage. More than that, they are using this information to capture best practices for facility layouts, workflow layouts, and material flow. This is critical to address the number one challenge of varied employee skills and knowledge.

Again, the benefits are twofold. Capturing best practices and centrally managing them means they can be reused and applied to new jobs in ways that save time. It also ensures that effective and proven practices and processes continue to be leveraged in the manufacturing process.

Table 8: Planning and Enabling Reuse

	Best-in-Class	Industry Average	Laggard
Process	Capture and document guidelines and best practices for material flow on factory floor		
	56%	**43%**	**11%**
	Capture and document best practices for workflow layouts		
	46%	**38%**	**14%**
	Capture and document best practices for facility layouts		
	46%	**31%**	**20%**
Knowledge Management	Centrally manage and control workcell designs		
	73%	**40%**	**36%**
	Central access to schedules for machine tools usage		
	73%	**40%**	**26%**
	Centrally manage and control plans for facility layout		
	70%	**44%**	**43%**

Source: Aberdeen Group, September 2008

Key Takeaways

The practices implemented by the Best-in-Class address the top challenges companies face preparing for manufacturing as well as increasing the productivity of the manufacturing process itself. To realize similar benefits enjoyed by the Best-in-Class, manufacturers must adopt these same processes. Of the practices reviewed above, the core takeaways are:

- **Leverage the engineering BOM (eBOM).** The Best-in-Class are 32% more likely than the Industry Average to create the mBOM by reordering the eBOM to represents the order of production. The benefits realized here are enhanced by central location in PDM and include: improved productivity resulting from automation and greater confidence in the accuracy of the mBOM, particularly when

"Formally identifying work instruction best practices makes it easier for the people working on the floor to raise the red flag when something is wrong. In the past, we've run processes for three to four days before knowing a part was no good, but we can now identify problems within hours."

~ Plastics Engineer
Food / Beverage Manufacturer

manufacturing activities are planned concurrently with the development of product designs. This also addresses the challenge of frequent changes to engineering data.

- **Facilitate collaboration between engineering and manufacturing.** There are two key findings here: make the evaluation of manufacturability a formal step in the product development process and provide manufacturing and engineering each with access to more information from the other department. This helps optimize productivity and helps catch issues earlier, before they become problems as well as addresses one of the top challenges, lack of regard for manufacturability during design.
- **Go digital with facility and resource planning.** Remember, proper planning leads to optimized production. The Best-in-Class leverage a robust digital toolkit to improve efficiency and gain insights during facility layout. This includes manufacturing process planning tools (33% more likely than Laggards to use), 3D CAD to design workcell machinery (2.7-times more likely to use), and 3D layout of facilities (2.8-times more likely). This addresses a top challenged of fixed facility resources. A single source of information helps them here as well by ensuring that the information available for manufacturing planning most accurately reflects product designs.
- **Get work instructions right early to save time later on.** The story here isn't that different from facility layout. The Best-in-Class leverage 3D and central access to knowledge to save time planning and ensure that the processes themselves are optimized for manufacturing productivity. The ease of communication that comes with 3D also lets these leaders overcome differing skill sets and language barriers addressing the number one challenge of varied employee skills and knowledge.
- **Build on the value of robotics automation.** Many organizations look to robotics automation to improve productivity and efficiency in the manufacturing process. The Best-in-Class look to further develop these gains by focusing on improving the productivity of the automation planning process. Effectively, what this comes down to is that they are 43% more likely than the Industry Average to program machinery offline and more than twice as likely to simulate behavior to verify robotics perform as required in advance of the production process addressing the challenge of increased complexity.
- **Learn from what was done before.** The top challenge reported by respondents in Aberdeen's *The Computer Integrated Manufacturing View* study is varied employee skills and knowledge. Capturing and centralizing knowledge is an effective way to make information available to a wider group of employees. It is particularly telling to note that the Best-in-Class are well over twice as likely as Laggards to capture best practice for facility layouts, workflow layouts, and

the flow of material on the factory floor. Capturing this information saves time through reuse and ensures that optimized processes are leveraged.

For more information on this or other research topics, please visit www.aberdeen.com.

Related Research	
The Computer Integrated Manufacturing View September 2008	*Digital Manufacturing Planning* November 2007

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