Proving its Worth: Digital Manufacturing's ROI

EXECUTIVE SUMMARY

Summary

DHBA has documented a pattern of strong ROI derived directly from increased productivity – both in discrete sub-process steps and overall project performance. These improvements stem directly from the use of 3-D design and simulation of manufacturing processes.

We interviewed users in aerospace, automotive, heavy equipment, and shipbuilding industries. The results validate the potential benefits of manufacturing process design and simulation implementations. They also provide limited, preliminary benchmarks to guide companies planning their own implementations of digital manufacturing software.

In a series of dialogues with leading users of digital manufacturing software, D.H. Brown Associates, Inc. (DHBA) has documented a pattern of strong return on investment (ROI) derived directly from increased productivity – both in discrete sub-process steps and overall project performance. These improvements stem directly from the use of 3-D design and simulation of manufacturing processes.

Our interviews involved users in **aerospace**, **automotive**, **heavy equipment**, and **shipbuilding** industries. The results validate the potential benefits of manufacturing process design and simulation implementations. They also provide limited, preliminary benchmarks to guide companies planning their own implementations of digital manufacturing software.

PRODUCTIVITY IMPROVEMENTS

Discrete Processes		
Process	***Industry***	***Improvements***
Tool Design	Aerospace	75% reduction overall in time and labor
Castings	Heavy Equipment	50% reduction in errors from suppliers
Factory Line Layout	Automotive	20% reduction in retooling time
Robot Welding Line Layout	Automotive	85% reduction in changes required after implementation

Projects		
Project	***Industry***	***Improvement***
Produce First Set of Development Parts	Aerospace	58% reduction in time and labor (single test case)
New Process Learnout	Aerospace	96.8% reduction (single test case)

TABLE 1: Productivity Improvements through Digital Manufacturing – Discrete Processes and Projects

A summary of this report is available to all of our subscribers free of charge. Sponsors of our collaborative Product Definition and Commercialization (PDC) program receive the full report as part of our comprehensive services. Those interested in the program should contact Chuck Ditchendorf, Account Executive, at chuck @dhbrown.com or 914-937-4302, ext. 355.

In the most dramatic case, an aerospace equipment manufacturer reports shrinking process learnout from 125 flawed parts to 4 in a single test case.

The most dramatic results appear in a measurement of new process implementation time from an aerospace equipment manufacturer. This company reports shrinking process learnout (the number of parts manufactured before the part reaches sufficient quality) from 125 flawed parts to 4 in a single test case. Other impressive improvements include an 85% reduction in required changes to robotic welding lines in an automotive firm, and a 75% reduction in overall time and cost for tool design in an aerospace firm. All of these results remain directly attributable to the companies' use of 3-D design and simulation of manufacturing processes.

DHBA's findings place 3-D manufacturing process design and simulation squarely on the implementation road map for all large manufacturing firms.

Given these strong results in point processes and project-level results, the next challenge lies in achieving clear evidence of improvements in overall time-to-market and cost. Still, today's more limited findings justify further investigation of digital manufacturing's potential for dramatic benefits across many industries, and place 3-D manufacturing process design and simulation squarely on the implementation road map for all large manufacturing firms.

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It seems reasonable to predict that digital manufacturing will eventually mirror the strong benefits and positive ROI found with the application of digital 3-D techniques to the design engineering processes – e.g., visualization, modeling, and simulation.[1;2] In fact, the downstream business process application of 3-D technologies to manufacturing should ultimately offer even more dramatic advances given:

- Manufacturing's greater-scale savings potential (due to higher costs); and
- Manufacturing's historically limited use of low-level, fine-grained process simulation.

THE INTERVIEWS

DHBA interviewed customer decision-makers and vendor executives involved in ROI justifications for digital manufacturing software. Through ROI studies, companies seek to justify the often significant implementation, training, and cultural change costs associated with digital manufacturing. Our interviews focused on aerospace, heavy equipment, automotive, and shipbuilding firms. These industries face high manufacturing capital costs and complex assembly processes – the profile best suited to benefit from modern digital manufacturing tools. In addition to endorsing the decision to invest in digital manufacturing, our findings provide some initial guidance for companies embarking on their own ROI studies.

[1] *Visual Portals over the Supplier Web: Current Capabilities and Strategic Potential,* D.H. Brown Associates, Inc., August 1999.
[2] *Visual Portals: Unlocking Product Information,* D.H. Brown Associates, Inc., February 1999.

THE SOFTWARE

Defined as the process of using 3-D Computer-Aided Design (CAD) models and associated information for visualizing, modeling, and simulating the manufacturing processes, digital manufacturing allows companies to develop and test their manufacturing processes in a computer's virtual environment – saving both development time and money. Historically, companies performed these manufacturing functions through slow and costly techniques such as paper and pencil, high-level data processing techniques, and physical prototyping and implementation. Although beneficial once adopted, digital manufacturing's software, hardware, and labor resource requirements all result in significant up-front implementation costs. Frequently, the dramatic business process changes along with extensive training force companies to undergo a cultural change in order to fully implement a digital manufacturing system. In addition, companies must often spend additional time and effort developing their own new business processes for use with the available digital manufacturing software.

Although beneficial once adopted, digital manufacturing's software, hardware, and labor resource requirements all result in significant up-front implementation costs.

TABLE 2: Typical Digital Manufacturing ROI Considerations

Costs	Benefits
➢ Digital Manufacturing Software	➢ Quicker Time to Market
➢ Computer Hardware	➢ Less Per Unit Product Cost
➢ New Business Process Development	➢ Less Overall Labor Cost
➢ Cultural Change Implementation	➢ Higher Quality Manufacturing Process
➢ Software Training	➢ Lower Manufacturing Process Development Cost
➢ New Business Process Training	➢ Less Rework; Quicker Part Learnout
➢ Process Spin Up*	➢ Higher Reuse of Existing Manufacturing Equipment; Eliminating Some Existing Computing Systems

*Spin-Up refers to the extra labor required to achieve proficiency and strong functionality in a new business process and software.

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INDUSTRY APPLICATIONS

In DHBA interviews, aerospace, heavy equipment, and automotive companies all report successful ROI analyses that justified the purchase implementation of a digital manufacturing system.

DHBA interviewed users in four industries: aerospace; heavy equipment; automotive; and shipbuilding. In all cases except shipbuilding, customer companies reported successful ROI analyses that justified the purchase and implementation of a digital manufacturing system. They undertook studies at a project or pilot level and then extrapolated to program-wide savings. The detailed manufacturing business processes discussed included welding, machining, casting, assembly/disassembly process development, manufacturing line layout, off-line robot programming, numerical control (NC) programming, tolerance analysis, and ergonomic analysis. Shipbuilding presented a unique case: digital manufacturing was mandated by the customer, so no ROI studies were performed.

TABLE 3: Typical Digital Manufacturing Industries and Business Processes

Industries	Business Processes
➢ Aerospace	➢ Welding
➢ Heavy Equipment	➢ Machining
➢ Automotive	➢ Casting
➢ Shipbuilding	➢ Assembly Process Development
	➢ Disassembly Process Development
	➢ Manufacturing Line Layout
	➢ Off-Line Robot Programming
	➢ NC Programming
	➢ Tolerance Analysis
	➢ Ergonomic Analysis

Several companies continued to apply metrics after implementation and have developed actual-results ROI to confirm their initial justification estimates. While precise, high-level process savings were identified for some key digital manufacturing processes, the small survey sample resulted in a lack of cross-correlation. Citing competitive sensitivity, all companies interviewed to date declined to share their final, detailed data for verification purposes. However, as companies deploy digital manufacturing techniques more broadly across competitive boundaries, they should become increasingly willing to share such detailed information.

AEROSPACE APPLICATIONS

An aerospace company with a serious commitment to digital manufacturing reports that its effort to demonstrate productivity improvements through ROI analysis plays a significant role in convincing workers to undertake process change.

Demonstrating a serious commitment, one aerospace company has made digital manufacturing a part of its high-level business process improvement goals. The company employs a master 3-D CAD model and makes it available to downstream manufacturing design and simulation processes. This approach enables digital analysis of tolerances, concurrent tool design, NC programming, machine simulation, off-line computerized milling machine (CMM) programming, simplified work instructions, and automatic part inspection. According to the company, its effort to demonstrate productivity improvements in these processes through ROI analysis plays a significant and ongoing role in convincing workers to undertake process change. It reports benefits in the areas of reduced learnout, faster tool designs, and quicker production of the first set of development parts. The company believes that its combined use of 3D master CAD models and digital manufacturing tools has been the pivotal enabler in allowing it to reduce total product development time by 40%, and its total cost of new product development by 70%.

Another aerospace company uses digital manufacturing techniques for more discrete analyses. The company performs studies such as tolerance, assembly, and ergonomic analysis as required by the various programs, but it does not tie all these analyses together for all programs. A ROI study on the effectiveness of such analyses revealed reductions in labor time and cost for design, manufacturing, and maintenance.

In the opinion of one aerospace company representative, engineering processes in highly advanced manufacturing firms have reached a productivity plateau through their aggressive implementation of leading-edge tools. Manufacturing, therefore, once again presents the next opportunity for significant improvement. Now manufacturing can concentrate on leading-edge process design and simulation, leveraging this technology for both discrete process simulation and program-wide initiatives.

TABLE 4:
Typical Digital Manufacturing Process Improvement for Aerospace

Industry	Business Process	Process Improvement
Aerospace	Tool Design	75% savings in time (& labor) [actual]
	Produce First Set of Development Parts	42% savings in time (& labor) [goal]
	Produce First Set of Development Parts	58% savings in time (& labor) [single test case]
	Learnout	90% improvement [goal]
	Learnout	96.8% improvement [single test case]

HEAVY EQUIPMENT APPLICATIONS

The heavy equipment manufacturer we interviewed employs discrete simulation for machining, measuring, and assembly. The company also performs work in NC and off-line robot programming, and is studying assembly planning using digital manufacturing techniques. Prior to each discrete project, the company undertakes ROI analyses to verify the cost-effectiveness of performing the simulation work.[3] It reports improving the production of castings by 50%-70% through its use of a simulation tool.

Currently, this company remains involved in internally selling the use of digital manufacturing applied to an overall business process change. Prior to enacting a complete business process change implementation, several vendor products must come together across the entire system – no off-the-shelf complete solution exists. Advocates within the company are focusing on error reduction as their key metric for justification. They face two key hurdles to achieving internal acceptance of an overall process change – the ROI and cultural change required.

TABLE 5: Typical Digital Manufacturing Process Improvement for Heavy Equipment

Industry	Business Process	Process Improvement
Heavy Equipment	Castings	2 to 1 error reduction from suppliers [actual]

AUTOMOTIVE APPLICATIONS

One automotive company reports heavy involvement in the implementation of various 3-D, digital manufacturing initiatives. Its primary barrier stems from the lack of an entire solution-based approach to digital manufacturing products and services. Currently, companies must devise much of the solution and business process change themselves, without a full-capability vendor partnering resource. However, when such individual investments are made, dramatic improvements can result. For example, the automotive company found that 85% fewer changes in a robot welding factory line occurred under digital manufacturing, as compared to historical data for a non-digital manufacturing approach.

TABLE 6: Typical Digital Manufacturing Process Improvement for Automotive

Industry	Business Process	Process Improvement
Automotive	Factory Line Layout	5 to 4 savings in retooling time [actual]
	Robot Welding Line Layout	20 to 3 reduction in changes required after implementation [actual]

[3] The results from most of these ROI analyses remain proprietary information.

SHIPBUILDING APPLICATIONS

One shipbuilder explained that their work has moved beyond the ROI stage, as their customer (the U.S. Navy) simply mandated manufacturing line simulation as a precondition for the contract. According to the shipbuilder, operators typically require six months to learn the software. Interestingly, this six month lag exists even though the company already makes extensive use of visualization in the design engineering stage. The shipbuilder notes a future need for greater guidance in effectively deploying digital manufacturing techniques, as they were required to invent new business processes entirely on their own for this implementation.