Transforming Manufacturing Engineering in the Aerospace & Defense Industry

Jim Brown | President

Foreword

Maximizing Production Capability in Aerospace & Defense with Virtual Build

With global borders reopened over the last year, the demand for transportation and logistics have peaked in comparison to the years before. Original equipment manufacturers (OEMs) in the aerospace and defense industry carry the brunt for this renewed demand and are faced with the decision to either accelerate production or risk missing business opportunities, causing reputational damage or losing relevance.

Businesses manufacturing components for aircraft, ships, spacecraft, weapon systems, and defense equipment need to maximize production capacity without compromising quality. In this report, we collaborated with Jim Brown, president of Tech-Clarity to explore how the increased use of virtual solutions has played a key role in driving top performers in manufacturing. By digitalizing processes in manufacturing planning and equipping engineers with capabilities to build and simulate 3D virtual prototypes, companies can create significant value in terms of time and cost savings among other benefits.

Based on the survey results detailed in this report, we take an in-depth look at:

- The most important aspects that drive product success and profitability
- Key challenges in process design and manufacturing engineering
- Opportunities to drive improvement for manufacturers
- Potential business value created among top performers
- Recommendations and next steps for manufacturers

We hope that you will gain much insight from this informative report. We are confident that you will be able to put what you have learned here to good use in driving effective transformation across your organization, which will unlock the path to manufacturing that is efficient, agile, resilient, sustainable and profitable.

Foreword

About DELMIA:

DELMIA is powered by the **3D**EXPERIENCE platform, delivering solutions to collaborate, model, optimize, and execute supply chains, manufacturing, logistics, and service. We connect the virtual and real worlds to enable customers with new levels of intelligence and decision making.

About DELMIA's virtual build solutions:

DELMIA virtual build solutions focus on technology and process that can bridge the gap between manufacturing and engineering by satisfying customer demand and capturing market share without sacrificing profit or quality.

Improve Manufacturing Engineering Performance

Improve Performance in the Face of Complexity

How can Aerospace & Defense companies improve manufacturing engineering? We surveyed 177 people directly involved with manufacturing engineering and found that modernizing processes and technology drives higher manufacturing engineering productivity and performance. These improvements are crucial to profitability as customers demand high quality, more personalized products at increasingly faster time to market; all despite rising product and manufacturing complexity.

Modernize Manufacturing Engineering

Survey results show that Top Performers (see definition on page 10) in manufacturing engineering have increased maturity in the way they plan, validate, and communicate manufacturing operations. These leading companies waste less time on non-value-added activities, find issues sooner, and spend less on physical prototypes. They accomplish this through best practices, including:

- More advanced collaboration and communication methods
- Increased use of 3D and simulation to plan and validate manufacturing operations with virtual, digital twins

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Improve Manufacturing Engineering to Increase Profitability

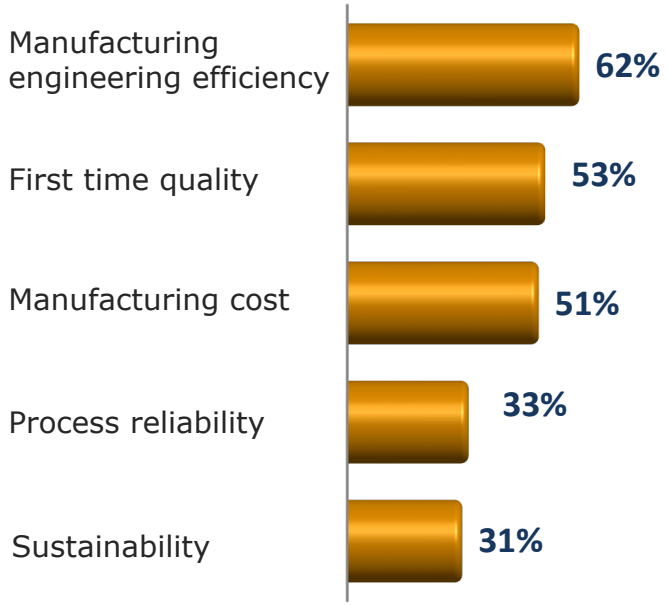
Product Profitability Relies on Speed, Cost, and Quality

Developing profitable products in today's Aerospace & Defense market is challenging. Manufacturers have to move quickly to out-innovate their competitors without sacrificing product cost and quality. Our research[1] shows that achieving product development success relies on meeting a combination of targets. According to this prior survey, the top business success and profitability drivers include faster product development, lower product cost, and increased product quality. Each of these goals is challenging, and companies need to meet them simultaneously.

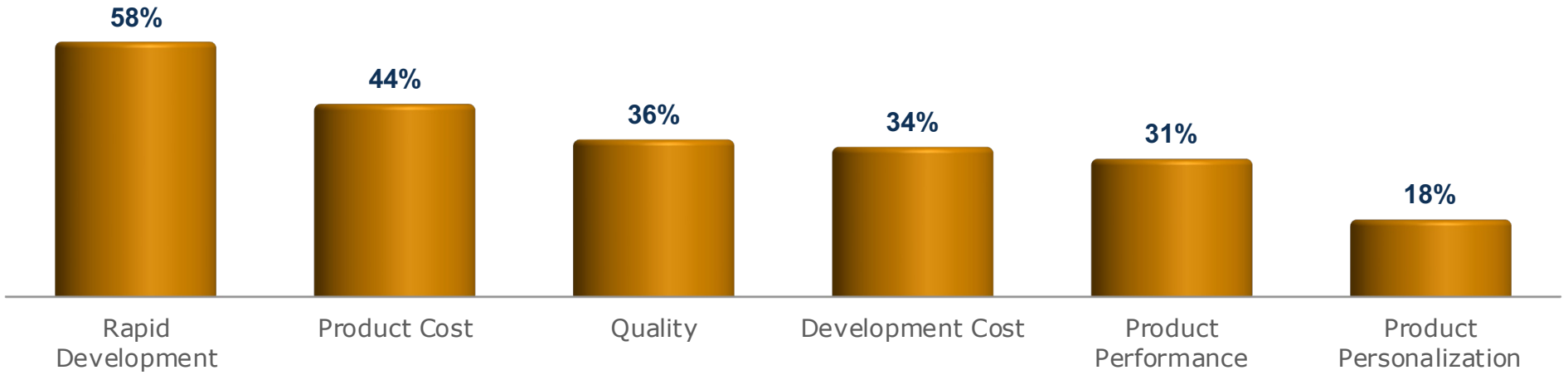
Manufacturing Engineering's Contribution

With that in mind, we investigated the role manufacturing planning plays in achieving these product development goals. Respondents indicate that efficiency, quality, and cost most drive product success and profitability. The two most commonly reported items, manufacturing engineering efficiency and first time quality, are valuable on their own. But it's important to recognize that both impact the time it takes a product to reach the market. The third most commonly reported factor, manufacturing cost, directly impacts product profitability. These make improving manufacturing engineering efficiency and performance strategic.

MANUFACTURING PLANNING ASPECTS THAT MOST IMPACT PRODUCT SUCCESS AND PROFITABILITY

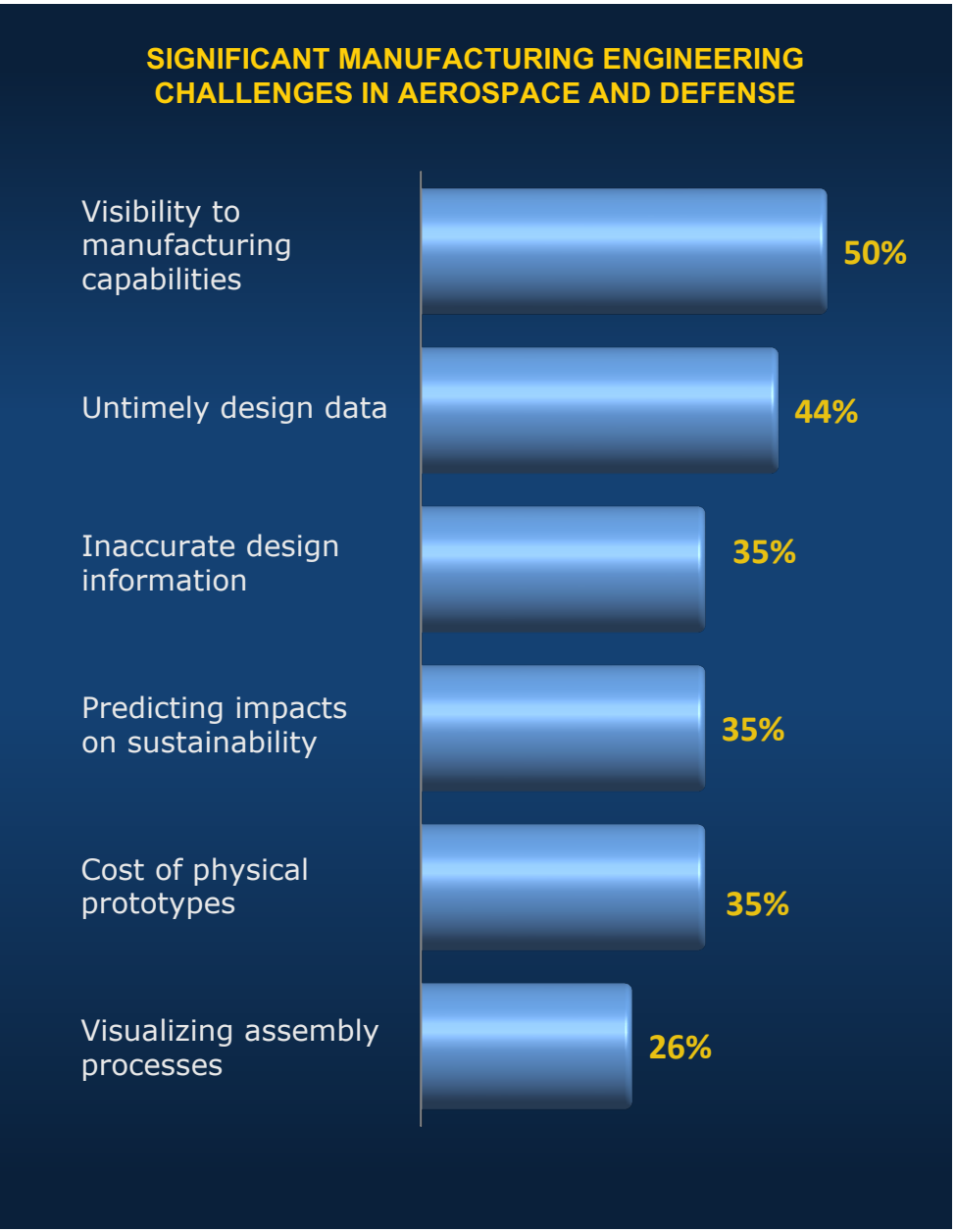


MOST IMPORTANT PRODUCT DEVELOPMENT SUCCESS AND PROFITABILITY DRIVERS[1]



Tech-Clarity

Address Process Designer Challenges



Manufacturing Engineers Face Increased Complexity

Manufacturing is more complex than ever. Complexity has increased in three areas; products, manufacturing processes, and markets. Today's products are offered with increasing numbers of variants and configuration options and require a combination of mechanical, electrical, and software components. Today's production environment is more distributed, frequently relies on contract manufacturing, includes industrial additive manufacturing capabilities, and involves increased automation. Finally, Aerospace & Defense companies are shifting production and reshoring as the industry is trying to cope with supply chain issues. Despite these, manufacturing engineers need to decrease cycle times and improve quality.

Challenges Reflect Lack of Information and Visualization

Manufacturing engineers must overcome significant challenges to design and validate production processes. The three most commonly reported challenges are lack of visibility to manufacturing capabilities, untimely product design data, and inaccurate design information. These issues hamper accurate, timely process design because planners can't access information about either the products to be manufactured or the work cells, equipment, tooling, and other resources to produce them.

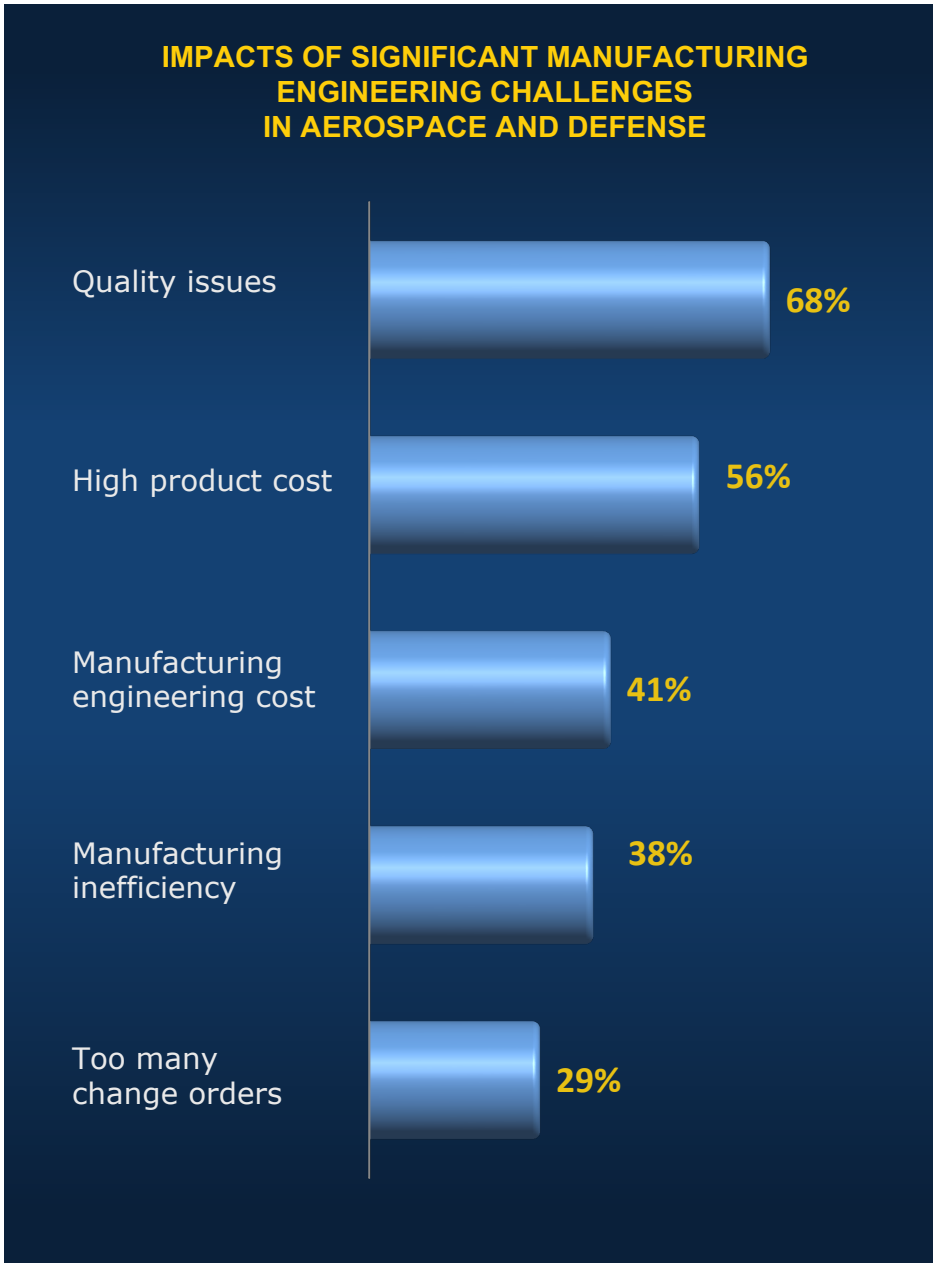
In addition, respondents report challenges predicting the impact of their decisions on sustainability, the cost to build physical prototypes, and the ability to visualize assembly processes.

Address Process Designer Challenges

Challenges Drive Inefficiency, Cost, Quality Problems

The challenges identified impact manufacturing engineers' ability to make accurate, timely decisions on production processes. They result in business-level impacts to quality, product cost, manufacturing engineering cost, manufacturing efficiency, and the number of engineering change orders (ECOs). These issues directly hamper the ability to achieve the product profitability and success drivers identified earlier.

Modern manufacturing engineering software platforms leverage virtual, digital twins to address the challenges that impact profitability.



Address Process Designers Challenges

Too Much Wasted Time

Survey respondents identified manufacturing engineering inefficiency as both a challenge and profitability requirement. Researchers further inquired about the amount of manufacturing engineering time that participants estimate their companies spend on non-value-added activities, including:

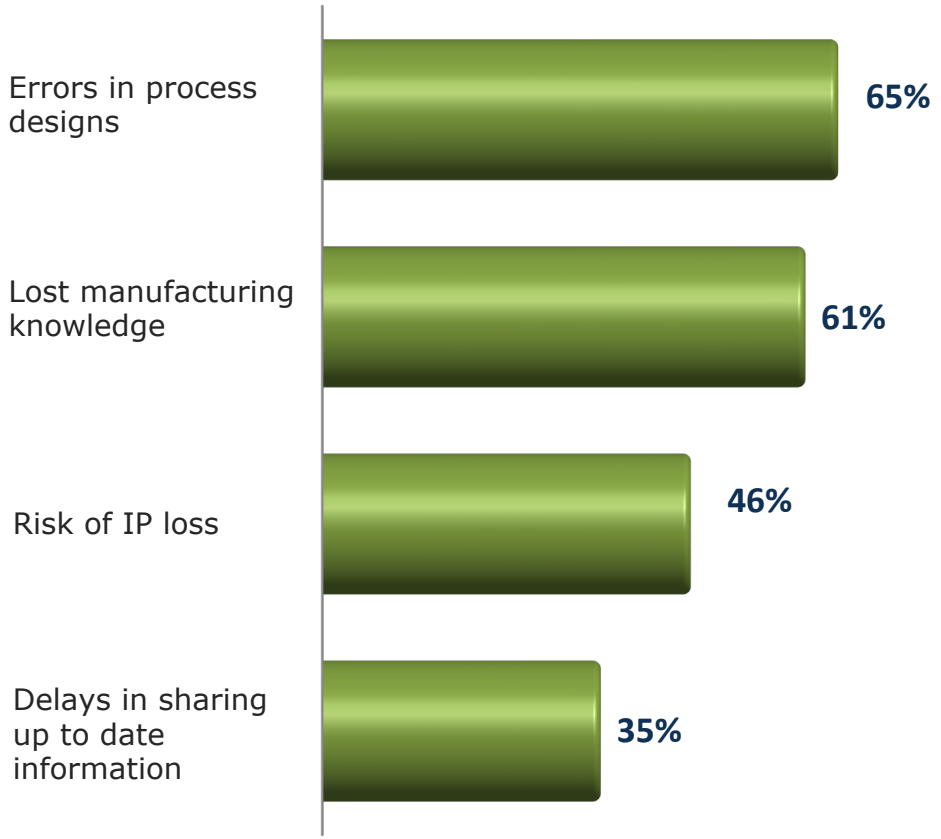
- Searching for data
- Rekeying information
- Recreating data
- Documenting feedback for others
- Modeling common assets
- Other activities that don't involve engineering innovation and decision making

Participants state that, on average, 25% of manufacturing engineering time is spent on these non-value-added activities. This wasted effort points to a significant opportunity for improvement.

Contract Manufacturing Extends the Challenges

Researchers found that over one-half of respondents (56%) use contract manufacturers. These respondents were asked what additional manufacturing engineering challenges they face when working with contract manufacturers? The survey found that the most common risk is errors in process designs. These can result in delays and quality problems. They also uncovered some business-oriented challenges, including lost manufacturing knowledge and know-how and the risk of losing company intellectual property (IP). Advanced collaboration capabilities can help both retain manufacturing know-how and protect proprietary information.

ADDITIONAL CHALLENGES WITH CONTRACT MANUFACTURERS



25% of manufacturing engineering time is spent on non-value-added activities

Recognize the Opportunity

Manufacturing Engineering is Ready for an Upgrade

It's time for change. Aerospace & Defense companies must digitalize production planning to reduce cycle times, increase efficiently, and deliver quality. Companies need to adopt new techniques to validate manufacturing earlier in the process, in parallel with product design.

Current Processes can be Improved

There is significant room for improvement. The majority of companies validate process plans with time-consuming and expensive physical prototyping. Physical prototypes bring abstract designs into the real world so engineers can identify issues and improvement opportunities. Most companies also use spreadsheets, which are prone to errors and file-based so they are not conducive to collaboration. These approaches lead to late discoveries and expensive process validation.

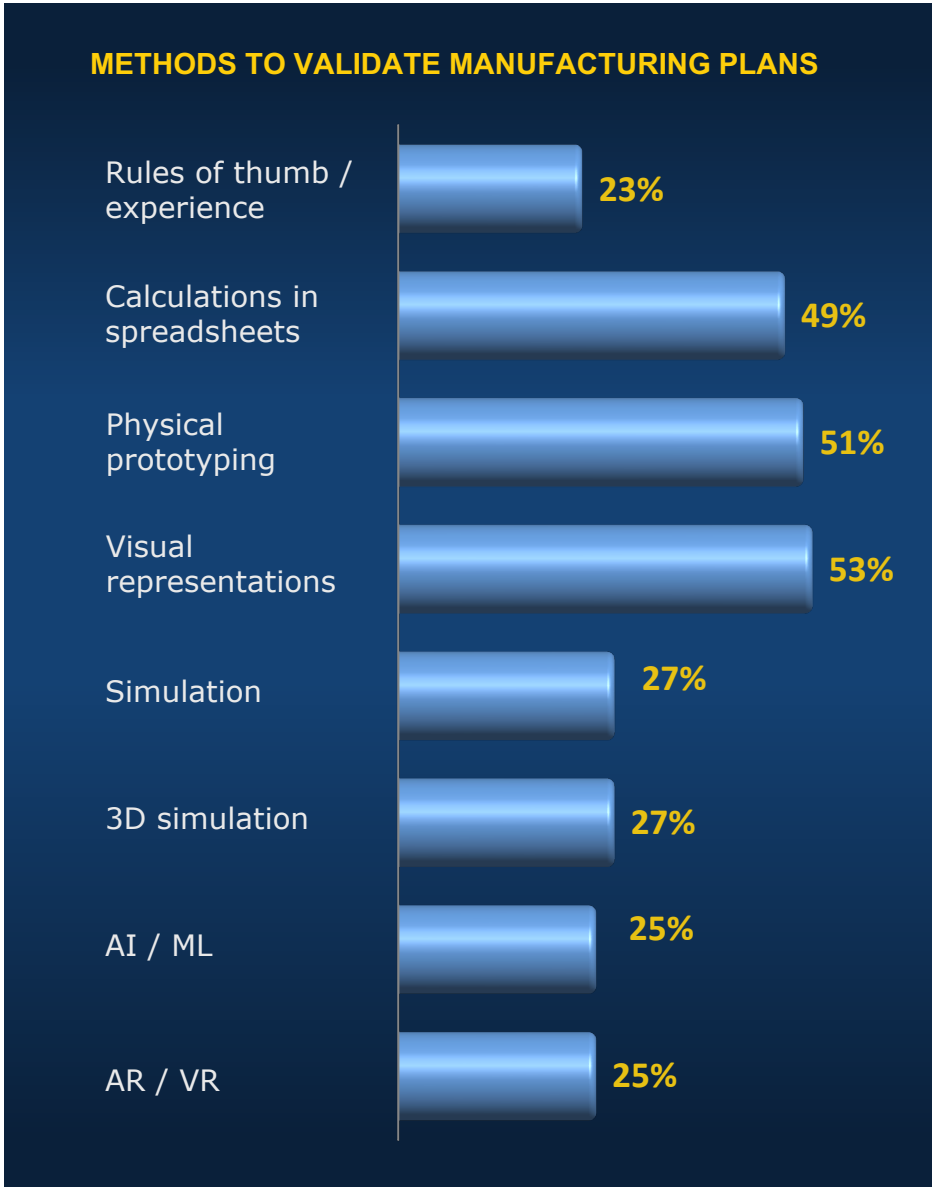
Leverage Visual Approaches

Trading physical prototypes for digital validation reduces time and cost. A significant number of companies already use some form of virtual representations. Static visualizations can help engineers see an issue in the digital world before committing to a physical prototype or manufacturing equipment.

Adopt Simulation and AR/VR

Beyond static images, virtual simulation helps designers go beyond "seeing" to virtually experiencing the production process. While only about one-quarter use either 2D or 3D simulation, it's a promising technology and a potential for significant planning and validation improvement.

Manufacturers are also beginning to explore the use of augmented reality (AR) to better visualize production processes in the context of existing equipment and infrastructure.



Quantify the Potential

Validating manufacturing processes with 3D and virtual simulation in Aerospace and Defense industry leads to:

39%
fewer prototypes

37%
less ECOs

36%
reduction in time to market

Estimate the Available Business Value

Change is hard and companies need to be confident that they will get a return for the efforts. They need to understand how much manufacturing engineering improvements will raise their performance and profitability. The answer varies by their unique products, manufacturing methods, and current process maturity.

Participants estimated their improvement in a variety of important metrics that impact business value. The researchers used percentages to account for different levels of complexity and unique company dynamics. Working in percentages also allows companies to apply the values to their own business to estimate the unique business value available to them.

The results show that validating manufacturing processes with 3D and virtual simulation technologies allows companies to eliminate about one-third of their physical prototypes, saving time and money. They can also reduce time to market by 36%, launching products faster to increase revenue and sales margins. In addition, they can minimize engineering change orders by just over one-third, saving time, money, and potential disruption. These improvements add up to significant business value!

Identify Performance Drivers

Top Performers are the companies with the top one-third of overall manufacturing engineering performance scores

Discover Best Practices

What should manufacturers do to gain these valuable business advantages? Analysts used a benchmarking process we call "Performance Banding" to identify best practices processes and technology for manufacturing engineering. Using this methodology, we looked at company performance against a number of metrics. For this survey, we used operational metrics that represent successful manufacturing engineering, including:

- Time to full production
- Product quality
- Manufacturing engineering efficiency (personnel)
- Manufacturing engineering cost (for example, cost of physical prototypes)
- Ergonomics and worker safety

Identify the Top Performers

Survey participants indicated their company's ability to hit these targets compared to their competitors. Researchers then created an aggregate metric representing an overall manufacturing engineering performance score. Then, analysts identified approximately one-third of the survey respondents with the highest scores as "Top Performers" and analyzed what they do differently from the lower performing companies, the "Others." The rest of the research report looks at what the higher performing companies do differently to help us make improvement recommendations to the Others.

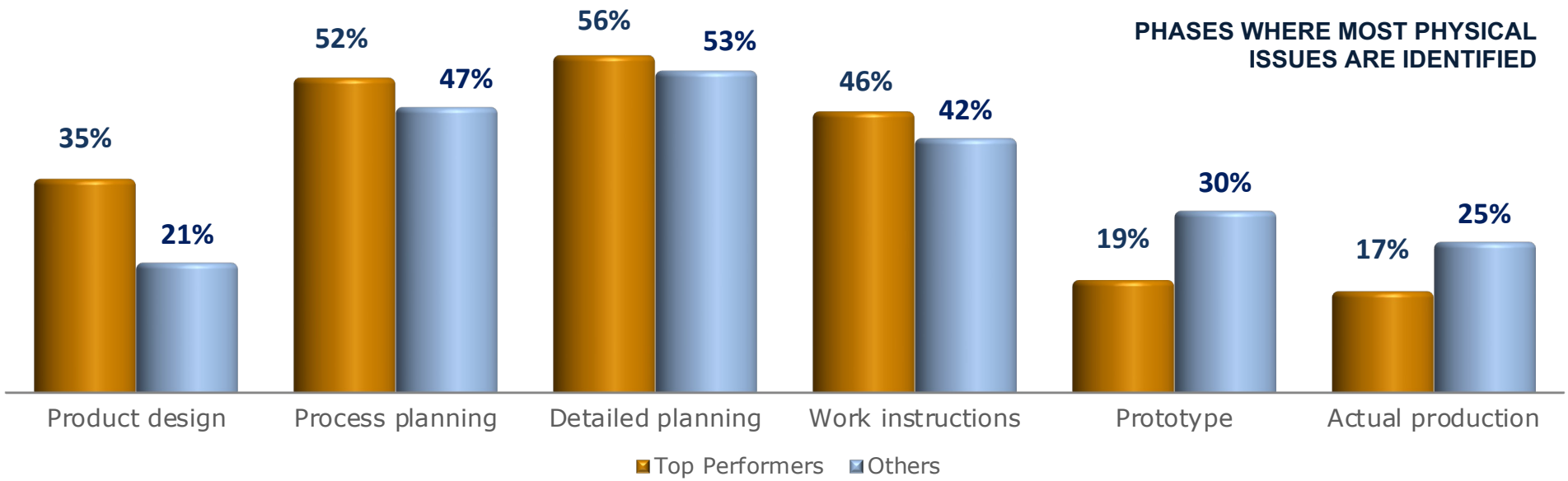
Find Issues Earlier in Design

Shift Left

Most manufacturers recognize that the sooner in the product lifecycle an issue is found, the lower the impact on the business. Late changes to product designs or manufacturing plans are exponentially more expensive than issues identified in a virtual environment before manufacturing lines, automation, and tooling are commissioned and workers are trained. On the other hand, companies that know they can accurately validate production plans are more confident to innovate and optimize products and manufacturing performance.

Top Performers can better find issues early, or "shift left," in time. They are 65% more likely to find physical issues during product design where changes are relatively easy to make. They are also more likely to identify problems in other early stages, including; process planning, detailed manufacturing planning, and work instruction development. Again, the sooner a manufacturability issue is found, the lower the negative impact on the business. On the other hand, Top Performers are 38% less likely to find the problems in the later prototype phase and 33% less likely to encounter them in production where errors are more costly. These findings indicate a significant advantage to Top Performers and likely contribute significantly to their higher performance level. The following sections will investigate how they accomplish this.

Top Performers are **more likely** to find issues early in product and process design, while Others are more likely to encounter problems later in the process, including the physical prototype phase and during actual production



Use more 3D and Simulation

Use 3D and Simulation to Improve Manufacturing Engineering

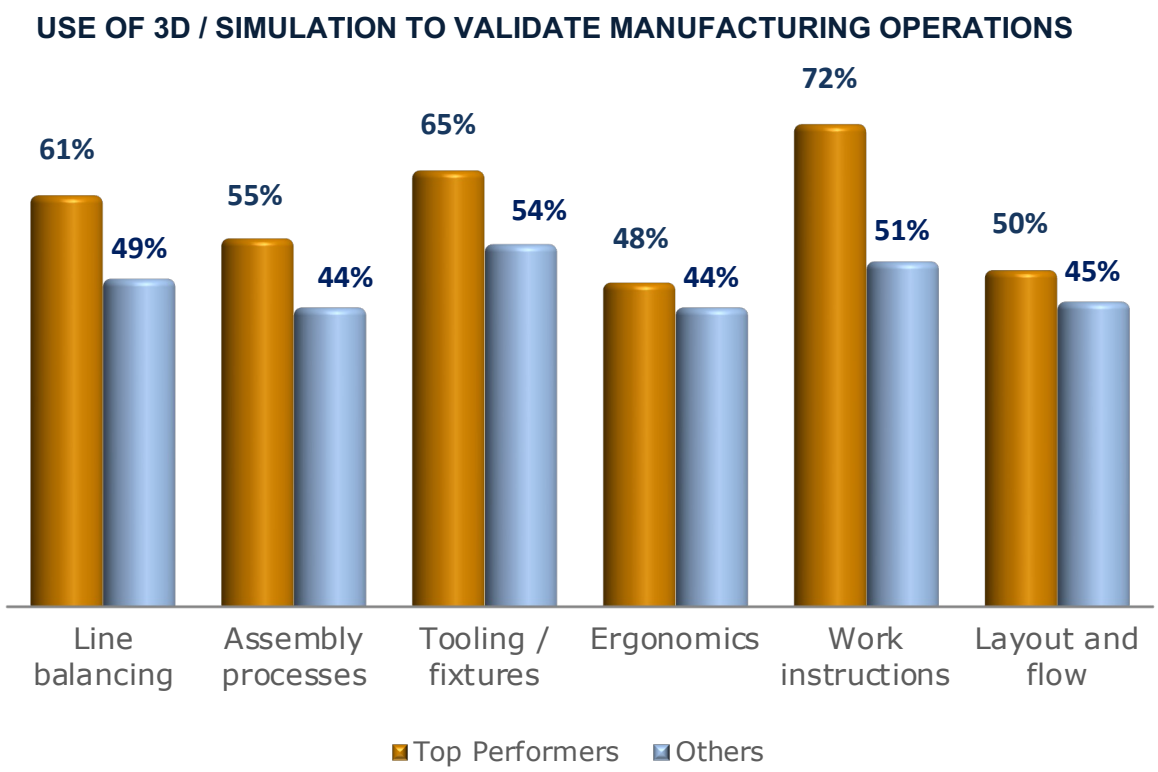
Manufacturing engineers need upgraded solution capabilities. Many companies are investing in digital twin technologies to make better predictions and decisions in a virtual environment. They leverage 3D modeling and simulation tools to make better decisions faster, without the time and cost of physical prototypes. It's time for manufacturing engineering to embrace virtual, digital twins.

The survey results show that Top Performers are more likely to use 3D and/or simulation in a number of manufacturing engineering processes, most notably:

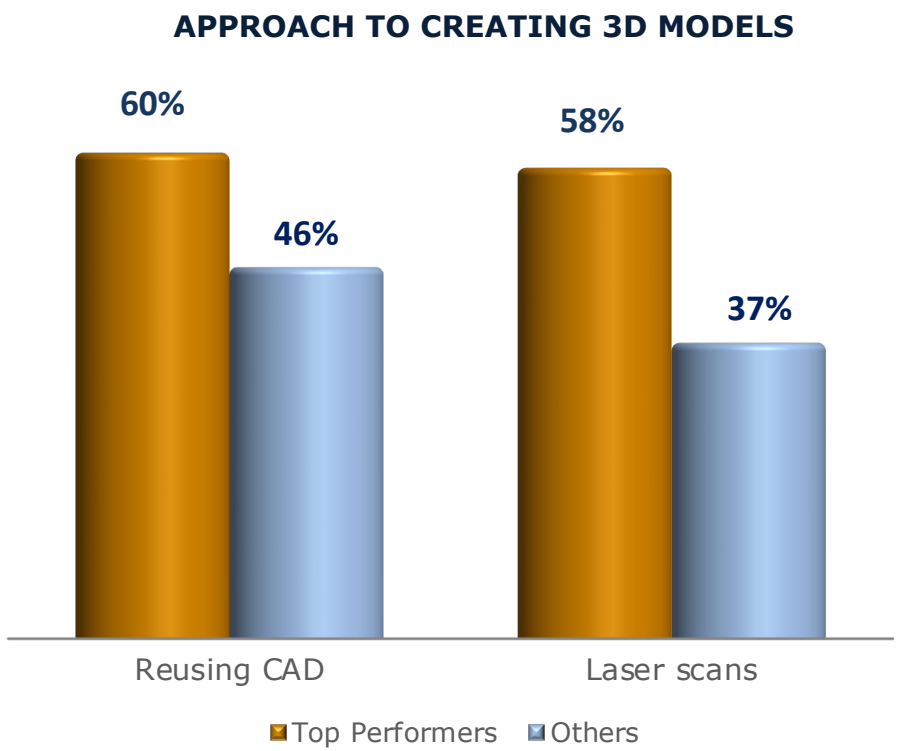
- 25% more frequently in line balancing
- 23% more commonly in assembly processing
- 40% more likely in work instructions.

As mentioned earlier, 3D and simulation help designers experience the product being manufactured in a virtual setting, allowing them to identify errors more naturally. This capability likely plays a significant role in helping them optimize processes and find issues sooner or shift left.

Top Performers are **more likely** to use 3D and/or simulation to validate manufacturing operations across a wide variety of manufacturing engineering process steps



Use More Advanced Ways to Support 3D / Simulation



Top Performers are **more likely** to support 3D and/or simulation in manufacturing engineering by reusing CAD or utilizing laser scanning instead of recreating models

Reduce the Barriers

The use of visualization and simulation to improve process planning is not a brand-new concept. But, it's one whose time has come. The investment required to develop 3D models for products, processes, and plants has dropped considerably. The learning curve to adopt the tools has also decreased.

Reuse Existing CAD Models

Leveraging 3D and simulation requires product, process, and production resource models. Creating these assets, effectively a digital twin of the production process, can be time-consuming unless manufacturing engineers can leverage pre-developed models. Production planners should gather CAD designs from design engineers, line builders, equipment manufacturers, or libraries of commonly used equipment. As evidence, Top Performers are 31% more likely to reuse CAD than Others.

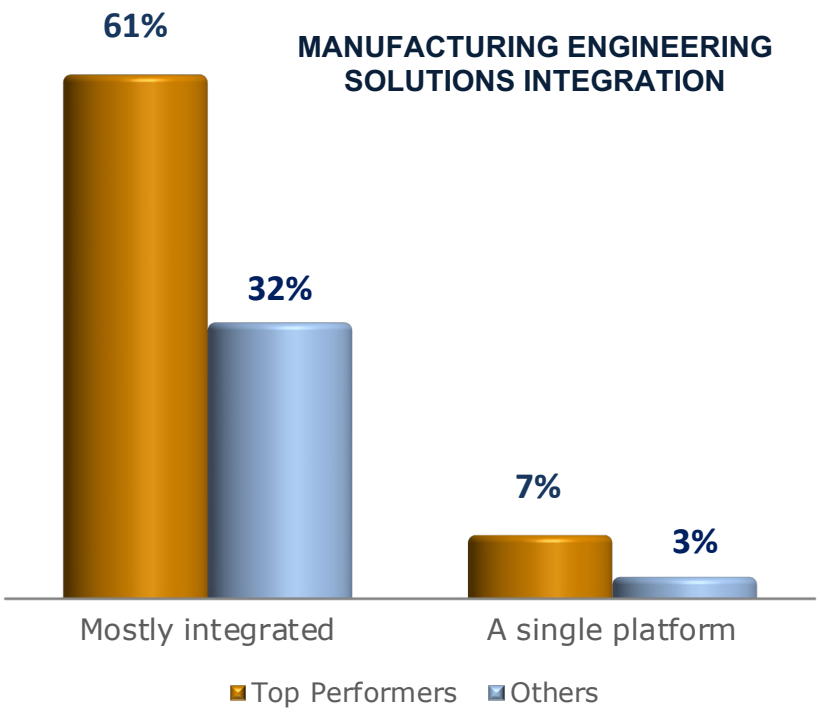
Augment CAD Models with 3D Laser Scanning

Companies can also leverage laser scanning technology for items without available CAD models, such as facilities. Laser scanning has become increasingly available and affordable to manufacturers of all sizes. Top Performers are 59% more likely to use laser scanning.

Both methods help overcome the challenge of poor visibility to product data and manufacturing resources, and help to enable the use of 3D and simulation.

Leverage More Integrated Solutions

Top Performers use **more integrated solutions** to support manufacturing engineering



Create a Digital Thread across Manufacturing Engineering

Another barrier that has dropped is the need to integrate or work around fragmented solutions. Each manufacturing engineering process step requires some amount of product, process, and manufacturing capability data. As discussed above, reusing models helps improve performance. Reuse is also valuable within the suite of solutions used by production planners. Disparate tools, however, make it hard to reuse designs and often result in recreating models. Recreating instead of reusing is inefficient and error-prone. It also limits agility because design changes can't be easily propagated along a cohesive digital thread.

Leverage a Platform of Manufacturing Engineering Solutions

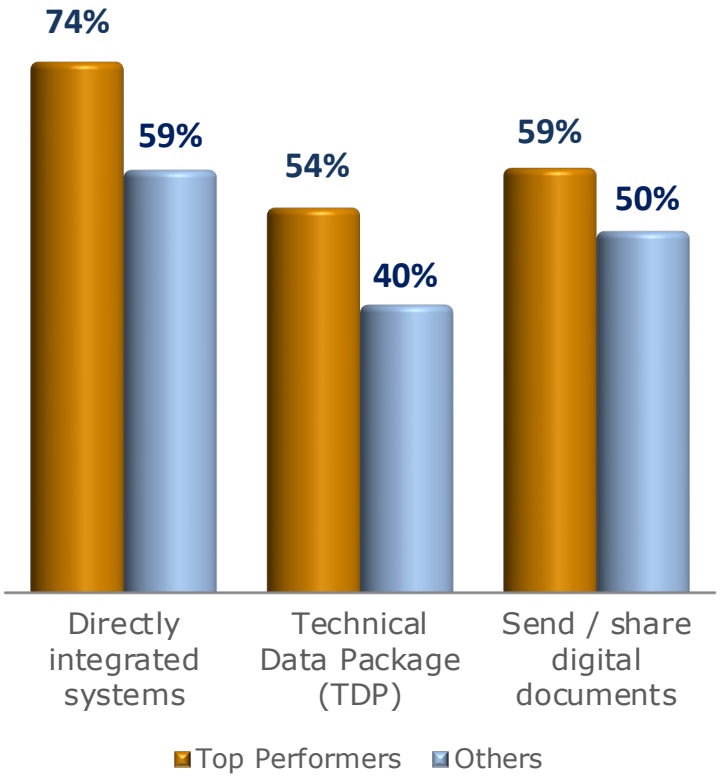
To create the digital thread without extensive need for custom integration, manufacturers should leverage integrated solutions, ideally from a platform of solutions. Top Performers are 90% more likely to use "mostly" integrated systems for manufacturing engineering. They are about twice as likely to use mostly integrated systems or a single platform. It's important to note, however, that although Top Performers are much more likely than Others to use a platform of solutions, only a small percentage (7%) of even the Top Performers have a single platform.

Use More Advanced Communication and Collaboration

Use More Advanced Methods for Instructions

Companies must effectively communicate manufacturing plans to ensure efficiency and quality. Manufacturing engineers use a variety of methods to share work instructions with the plant or contract manufacturers. Researchers found that Top Performers are more likely to use advanced approaches to communicate work instructions.

WORK INSTRUCTION COMMUNICATION



In particular, the Top Performers are:

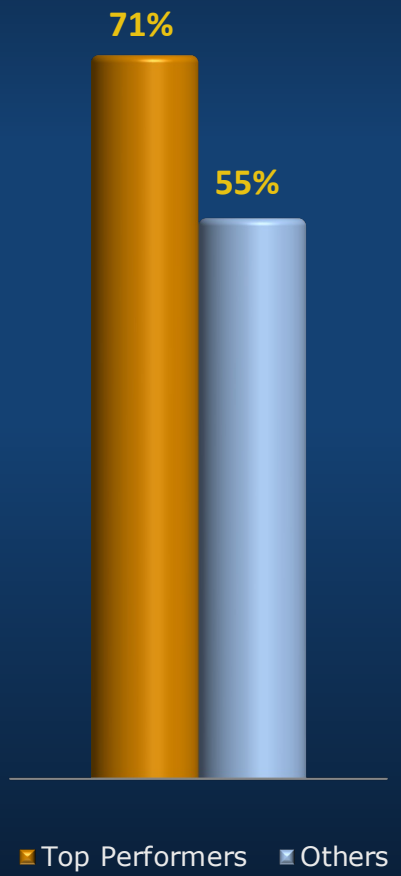
- 26% more likely to communicate manufacturing instructions in an integrated system
- 34% more likely to use technical data packages (TDP)
- 18% likely to send / share digital documents

On the other hand, Others were more likely to send non-digital files like scanned files, drawings, or other formats that are not readily accessible by other programs.

Top Performers are More Collaborative with Contract Manufacturers

Top Performers also work differently across corporate boundaries. Companies that use contract manufacturers were asked who primarily designs manufacturing processes for their contract manufactured products. One on extreme, companies may create manufacturing instructions and share them with their partner. Conversely, they may share product designs and trust the contracted organization to develop processes. Top Performers are less likely to use either of these methods. Instead, they are 29% more likely to work collaboratively with their contract manufacturer on manufacturing processes. This teamwork likely helps them overcome the previously mentioned challenges so they can retain manufacturing know-how internally and protect company IP.

COLLABORATIVELY DESIGN MANUFACTURING PROCESS WITH CONTRACT MANUFACTURERS



Top Performers Show the Way

Top Performers Have Transformed

The Top Performers, those with higher performance in time to full production, quality, efficiency, cost, ergonomics, and worker safety, have adopted more advanced approaches to manufacturing engineering. The data shows that these companies have adopted best practices, including more advanced collaboration, 3D, and simulation. In addition, they leverage more integrated solutions for manufacturing engineering.

Top Performers Prove the Value

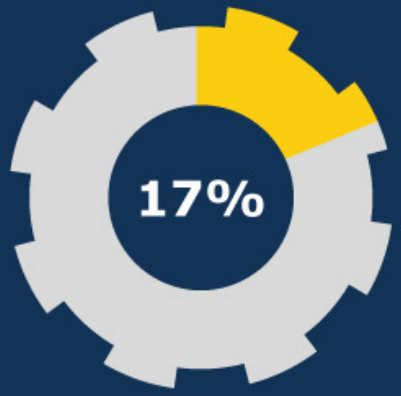
The Top Performers' better practices correlate with better manufacturing engineering results. As reported earlier, the leading companies are more likely to find physical issues in product design where they can fix them without considerable rework. Researchers also analyzed benchmark data on the amount of non-value-added time companies spend in manufacturing engineering, the cost of physical prototypes, and the average number of physical prototypes required for a product.

Top Performers showed advantages in all of these statistics. Researchers found, for example, that Top Performers spend 17% less time on non-value-added manufacturing engineering work. Further, they spend over 50% less on physical prototypes than Others through a combination of fewer and less expensive prototypes. However, these cost savings are only a portion of the potential value available from transforming manufacturing engineering because they don't include any other savings or revenue improvement from improved time to market.

Conclusion

Based on the benchmark results, researchers concluded that transforming manufacturing engineering with increased use of 3D and simulation to plan, validate, and communicate manufacturing operations leads to measurably better manufacturing engineering performance.

Top Performer Benefits



less time on non-value-added activities

lower spend on prototypes

Recommendations and Next Steps

Make a Strategic Improvement

Today's product, manufacturing process, and market complexity demand new ways of working. The Top Performers show are transforming manufacturing engineering through digitalization, better collaboration, 3D, simulation, and augmented reality allowing them to overcome efficiency, quality, and cost challenges. Using virtual, digital twins offers manufacturing engineers in the Aerospace & Defense industry both the ability to improve their own performance and a strategic opportunity to increase overall product development profitability. These leaders spend 17% less time on non-value-added activities in manufacturing engineering, directly reducing development cycle times.

Increase Quality

Responding companies indicate that they can reduce ECOs by over one-third. They do this by improving manufacturing process design using virtual technologies. Top Performers are more likely to find physical manufacturing issues in a virtual model than Others who are more likely to discover them in physical prototypes and actual production.

Reduce Cost

Survey respondents share that they can eliminate 39% of their prototypes by increasing manufacturing engineering maturity, leading to significant cost savings per product. They do this by shifting validation and issue identification sooner in the product development process so they need fewer physical prototypes.

Improve Time to Market

Survey respondents report that they can reduce time to market by 36% by using 3D and simulation to plan and validate manufacturing operations. This is done, in part, by increasing efficiency, reducing time-consuming physical prototyping, and lowering rework by finding issues sooner in product development.

Get Started

It's time to improve manufacturing engineering productivity and performance. Aerospace & Defense companies can follow the lead of the Top Performers to increase maturity in how they plan, validate, and communicate manufacturing plans. To increase maturity, manufacturers should adopt the best practices of the Top Performers, including using integrated solutions such as 3D and simulation for manufacturing engineering.

About the Research

Data Gathering

Tech-Clarity gathered and analyzed over 170 responses from people directly involved with manufacturing engineering through a web-based survey. Responses were gathered by direct e-mail, social media, 3rd party outreach, and online postings by Tech-Clarity and Dassault Systemes.

Industries

The respondents represent a variety of manufacturing industries. Researchers used the full dataset to generate general statistics and Performance Band data and then further evaluated 34 respondents that do business in the aerospace & defense industry to better understand unique industry challenges and savings potentials.

Company Size

The respondents represent a mix of company sizes, including 32% from companies with over 10,000 employees, 32% companies with 5,001-10,000 employees, 32% companies with 1,001-5,000 employees, and 4% companies with 1,000 or fewer employees.

Geographies

Responding companies report doing business in North America (34%), Western Europe (28%), Asia / Pacific Rim (24%), and others* including Australia, Eastern Europe, Latin America, Middle East, and Africa.

Company Role

98% of respondents research, design and/or manufacture products. The other 2% provide engineering or design services that support those efforts.

Role

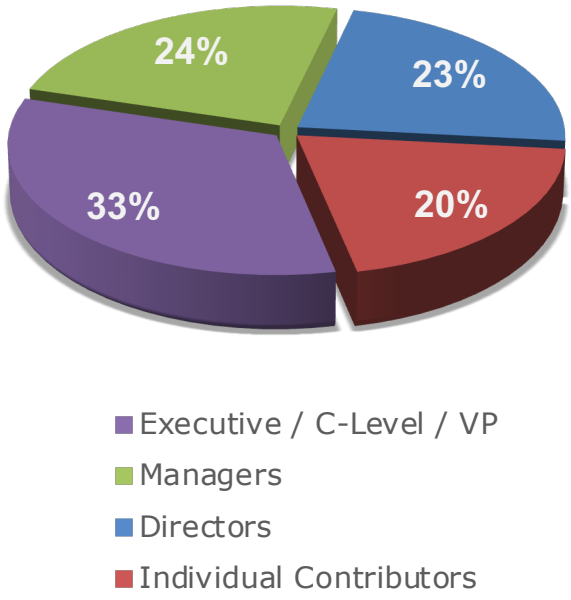
The respondents were 24% Manager level, 23% Directors, 23% VP level, 10% Executive / C-Level, and 19% Individual Contributors, and 1% Others.

Organizational Function

Of the respondents, 26% were in product management roles, 25% in Manufacturing, 17% in Product Design / Engineering, 13% in Industrial / Manufacturing Engineering, 8% in Industrial Design, the remaining 11% included a variety of organizations such as Analyst / Simulation Expert, Plant / Facilities Engineering, Project / Program Management, Information Technology (IT), and General Management.

* Note that the values may total greater than 100% because companies reported doing business in multiple industries and geographies.

The respondents represented a mix of company sizes and geographies.



Acknowledgments

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About the Author

Jim Brown founded Tech-Clarity in 2002 and has over 30 years of experience in the manufacturing and software industries. Jim is an experienced researcher, author, and speaker and enjoys engaging with people with a passion to improve business performance through digital enterprise strategies and supporting software technology.

Jim is actively researching the impact of digital transformation and technology convergence in the manufacturing industries.

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Tech-Clarity is an independent research firm dedicated to making the business value of technology clear. We analyze how companies improve innovation, product development, design, engineering, manufacturing, and service performance through the use of digital transformation, best practices, software technology, industrial automation, and IT services.

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1) Accelerating Product Development with the Cloud, Tech-Clarity, Jim Brown, 2020.

About this eBook This research is based on the cross-industry survey for "Transforming Manufacturing Engineering with Virtual Build" eBook and has been adapted for the Aerospace and Defense industry.

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