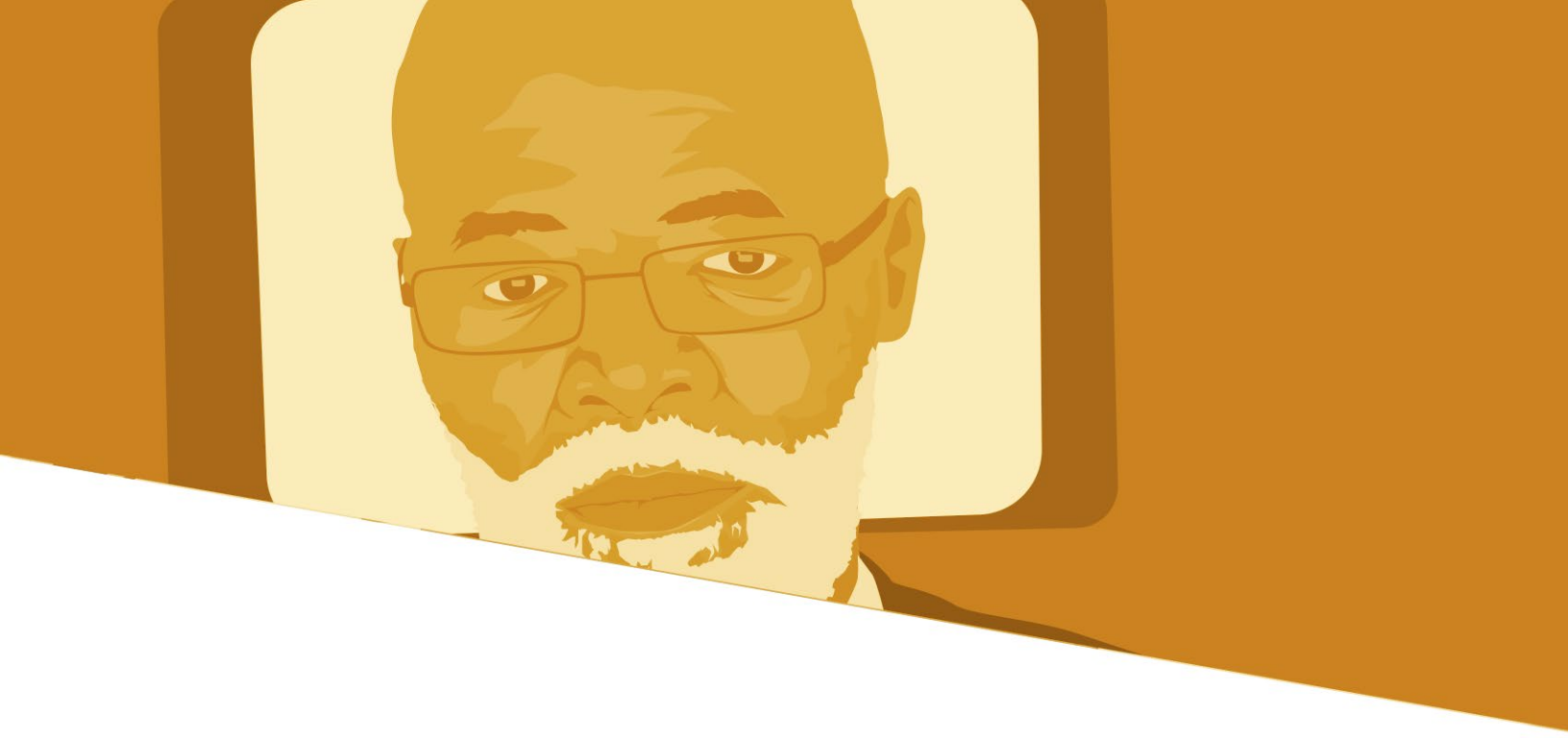
THE 2021 MBD BENCHMARK REPORT

MAXIMIZING THE ROI OF YOUR MBD EFFORTS

LIFECYCLE INSIGHTS





EXECUTIVE OVERVIEW

Every product development executive has to juggle time, tasks, and resources. In today's climate, however, leaders are consistently being asked to do more in less time and balance conflicting constraints. As noted in the 2020 Engineering Executive Strategic Agenda Study, 53% of respondents cited satisfying target requirements as a top challenge to development, while 45% noted that keeping up with schedules remains an obstacle to development success. It's no wonder that executives are seeking new ways to overcome these conflicts.

A model-based definition (MBD) is a 3D model annotated with product and manufacturing information (PMI), replacing the traditional drawing as design documentation. Model-based enterprise (MBE) initiatives, which use these annotated 3D models across a product's lifecycle, have been gaining momentum in manufacturing—and for good reason. Such initiatives provide support to help product development leaders better balance time and tasks at every step of the development process. However, not all manufacturers have implemented programs that allow them to get the most out of their MBD. In fact, some companies merely apply old drawing-based processes to these models, and then wonder why they don't see any benefits.

To help shed light on how manufacturers are pursuing MBD initiatives, Lifecycle Insights conducted the 2020 Model-Based Definition Study. The study found that most successful organizations not only create an MBD, but also employ model-based practices across procurement, manufacturing, service, and more to maximize the MBD's value.

This report publishes the findings from the study, including:

- Manufacturing organizations are making efforts to improve design documentation to meet today's new demands, including: accelerating time-to-market, avoiding unnecessary downstream delays and errors, and addressing complex requirements.
- To improve performance, the most progressive organizations are using MBD models in a range of model-based practices to source request-for-quote processes, develop numerically controlled machining and quality inspection tool paths, and author technical instructions.

With so many manufacturers working to optimize the product development process, it's important to understand what is truly required to get the most out of an MBD initiative. This study highlights that the value of an MBD initiative depends on how completely an organization implements it.

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DRIVERS OF DESIGN DOCUMENTATION CHANGE

As product development demands increase, leaders are looking for better ways to manage the overall process, including improvements to design documentation. Manufacturers are pursuing design documentation improvements, including MBE initiatives, to address the following key drivers: accelerating time-to-market, avoiding unnecessary downstream delays and costs, addressing complex requirements, and lowering production costs. But companies must recognize that development outcomes are heavily dependent on where, when, and how they are using MBD models.

INSIGHTS FROM THE STUDY

It is critically important to understand what is driving companies to make changes in product development. It gives us insight into their expectations of benefits and return-on-investment (ROI). Findings from the 2021 MBD Study provide several notable takeaways.

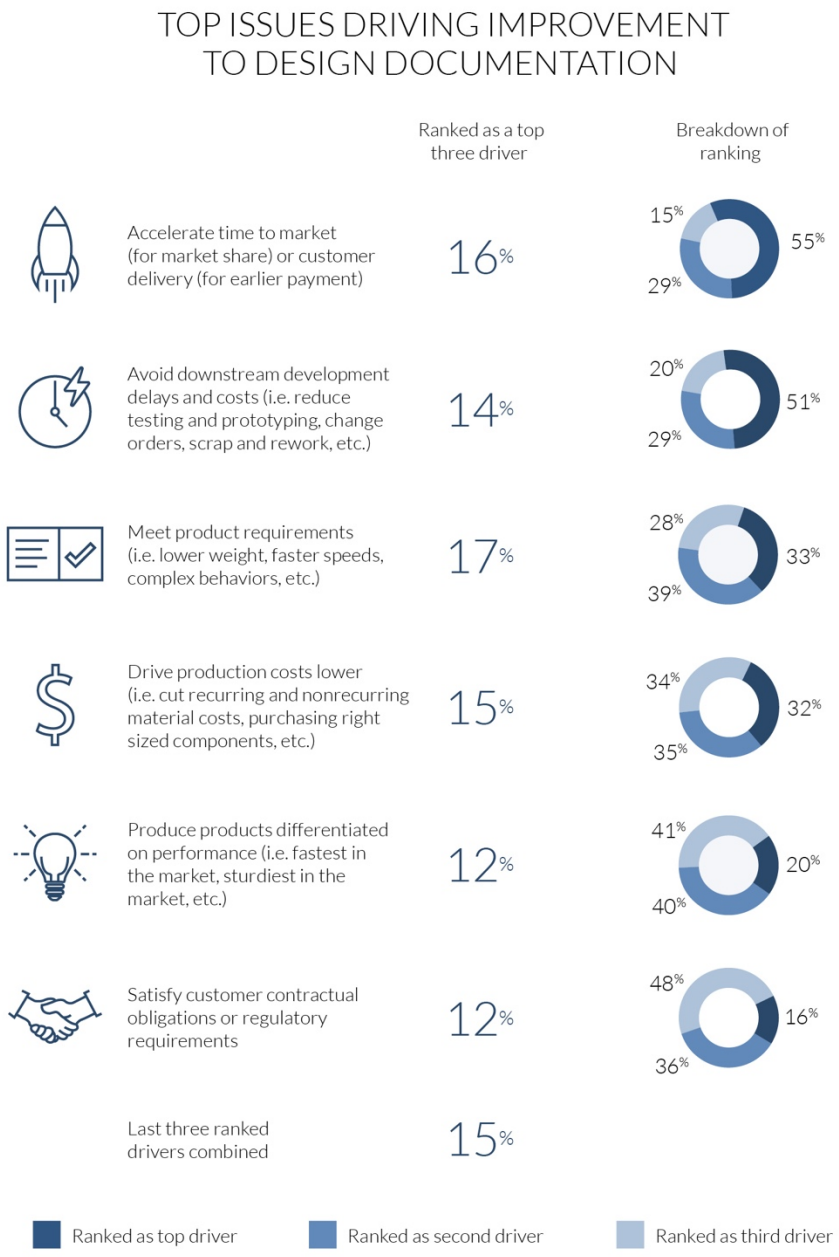


Figure 1: Accelerating time to market, avoiding downstream development delays and costs, and meeting product requirements are the top issues driving companies to improve design documentation.

- More than half (55%) of respondents in the 2020 Model-Based Definition Study cited faster time-to-market as the top goal of their design documentation improvement efforts. This clearly aligns with findings from the Engineering Executive Strategic Agenda Study, which found that engineers must comply with increasingly shorter development schedules.
- This particular issue was clearly acknowledged in this study. Fully 51% of survey respondents stated they were actively pursuing design documentation improvements to avoid downstream development delays and their associated costs.
- One-third of respondents reported that the top goal of their design documentation improvement efforts was to address increasing complexity. An additional 39% ranked it as their second most important objective.
- Lowering production costs ranked as the top driver behind design documentation improvements for 32% of respondents in the 2020 Model-Based Definition Study. Thirty-five percent cited it as their secondary goal.

ACCELERATING TIME-TO-MARKET

Executives are always looking for ways to condense development timeline without sacrificing quality. Unfortunately, there is no magic trick to aid them in this endeavor. But by focusing on the application of lean or value-based processes, where organizations re-engineer how they develop their products, they can often find ways to remove steps or activities that may be slowing them down without losing value. Manufacturers can also apply best practices and new technologies to accelerate the path to market.

MBD initiatives hold great promise to help on this front. They shorten the time it takes engineers to develop design documentation. They also reduce the number of errors and delays resulting from poor design documentation. More details on each of these fronts is detailed in the Applications of Model-Based Practices section.

Moving forward, companies that do not find ways to shorten their time-to-market will find themselves at a significant disadvantage as competitors launch or deliver their own products faster. They may also have to compromise on product requirements to differentiate their output. Both scenarios are detrimental to an organization's long-term success.

AVOIDING UNNECESSARY DOWNSTREAM DELAYS AND COSTS

While managing time is an important issue, it is not the only issue driving MBD adoption. Engineering creates design documentation that will be used by many other departments. Design documentation is used for manufacturing, quality, sourcing, service, and much, much more. Poor or inadequate design documentation with ambiguous requirements will result in errors downstream. This disrupts timelines and subjects companies to hard costs in the form of scrap, rework, and wasted materials as well.

Drawing-based design documentation is often to blame for such issues during the development process. When stakeholders do not have the proper skills and knowledge to correctly interpret this documentation, a variety of different problems arise. An MBD effort, however, eliminates many potential issues arising from skill or knowledge barriers, and provides automated use of semantic product manufacturing information (PMI).

There is also significant overlap with the first driver: accelerating time-to-market. When engineers can avoid the incorrect procurement of parts, they can shorten development schedules. The same is true of any other errors that may occur from the use of traditional, drawing-based design documentation.

As the design of modern products becomes more and more complex, manufacturers who are unable to avoid downstream development delays—and their associated costs—will miss crucial deadlines affecting launch and delivery. And with so many additional, yet potentially avoidable, costs, they will also be far less profitable.

ADDRESSING COMPLEX REQUIREMENTS

As organizations shift from traditional mechanical products to smart, connected ones, product requirements are only going to become more complex. And so will their documentation. It is increasingly necessary to communicate design intent clearly and concisely to other functional departments in the product development cycle. Having the right design documentation plays a critical role in this regard.

Manufacturing organizations need to produce design documentation that can clearly, accurately, and concisely represent design requirements from the very start of the development process. If they cannot, they risk costly delays.

LOWER PRODUCTION COSTS

Manufacturers can now leverage innovative new manufacturing methods that increase speed while lowering costs. These include new machining approaches and technologies—high-speed machining is just one example—and computer-controlled and non-contact quality strategies. But to get the most out of these methods, their software applications need to be able to directly use, interrogate, and work from accurate design documentation.

Companies that adopt more progressive production methods can significantly reduce production costs, making them more competitive in the marketplace. In doing so, they can advance their ability to launch and deliver on time, and boost overall profitability.

TAKEAWAYS ON MBD DRIVERS

Executives are caught between conflicting and competing constraints as they work to improve the product development process. It is becoming increasingly important to find ways to successfully satisfy the need for more complex product requirements while still delivering on shorter schedules. According to findings in the Engineering Executive Strategic Agenda, 71% of respondents plan to invest in design documentation improvements for mechanical hardware over the next year. Clearly, executives see the value in making the right changes to accelerate the product development process while avoiding unnecessary delays and costs.



BENCHMARKING DOCUMENTATION APPROACHES

As product development leaders look to address these consequential business drivers, MBD initiatives are becoming more popular. The move to MBDs is no longer a nascent effort, but rather a mainstream movement by a wide range of manufacturing organizations to adapt to and evolve with changing industry needs. Nearly half (46%) of survey respondents stated they had completed an MBD initiative.

Yet, despite that number, not every organization derives the promised benefits from those investments. In fact, there is a great disparity in the organizational performance of the companies pursuing these projects. The differentiating factor is the way that the companies implement MBD initiatives.

SPLITTING RESPONDENTS INTO GROUPS

In this benchmarking analysis, Lifecycle Insights used a two-stage approach to separate respondents into groups. To start, we separated the respondents who had not pursued an MBD initiative from those who had. Some 15% of the study respondents had been releasing an MBD deliverable

as design documentation at very low rates or not at all. Lifecycle Insights designated these respondents as the least progressive in their efforts.

Then, we split the remaining 85% into three distinct groups based on their adoption of different model-based practices across the development process. Respondents were awarded points for having adopted up to nine different conclusive practices. We averaged these points to provide a score on their progress. That score was then used to divide respondents into moderately progressive, highly progressive, and most progressive respondent groups.

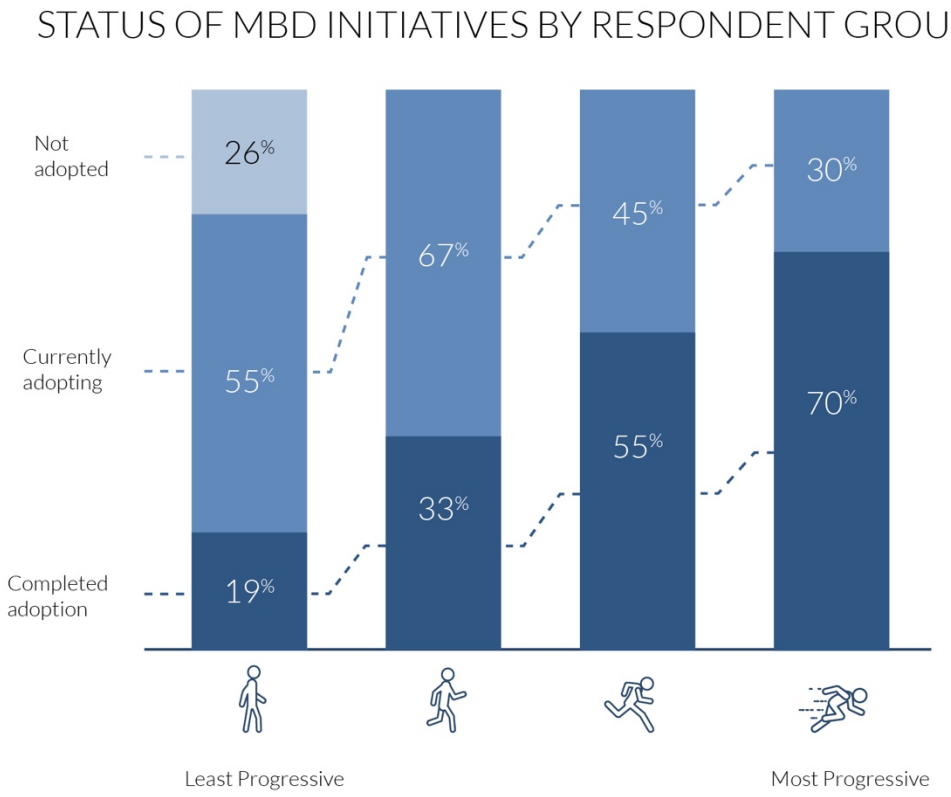


Figure 2: The study's respondents were split into four groups based on the maturity and productivity of their MBD initiatives.

As a further verification step, we averaged the adoption status of each respondent group. As expected, members of the most progressive group had a far more mature state of MBD adoption than those in the least progressive group.

DRAWING PRODUCTION

One of the key measures assessed in this study was the productivity of engineering teams developing an MBD compared to drawings. The study revealed that the most progressive, or those who had adopted the creation and consumption of MBDs more widely than others, could create these models much faster than they could a traditional drawing.

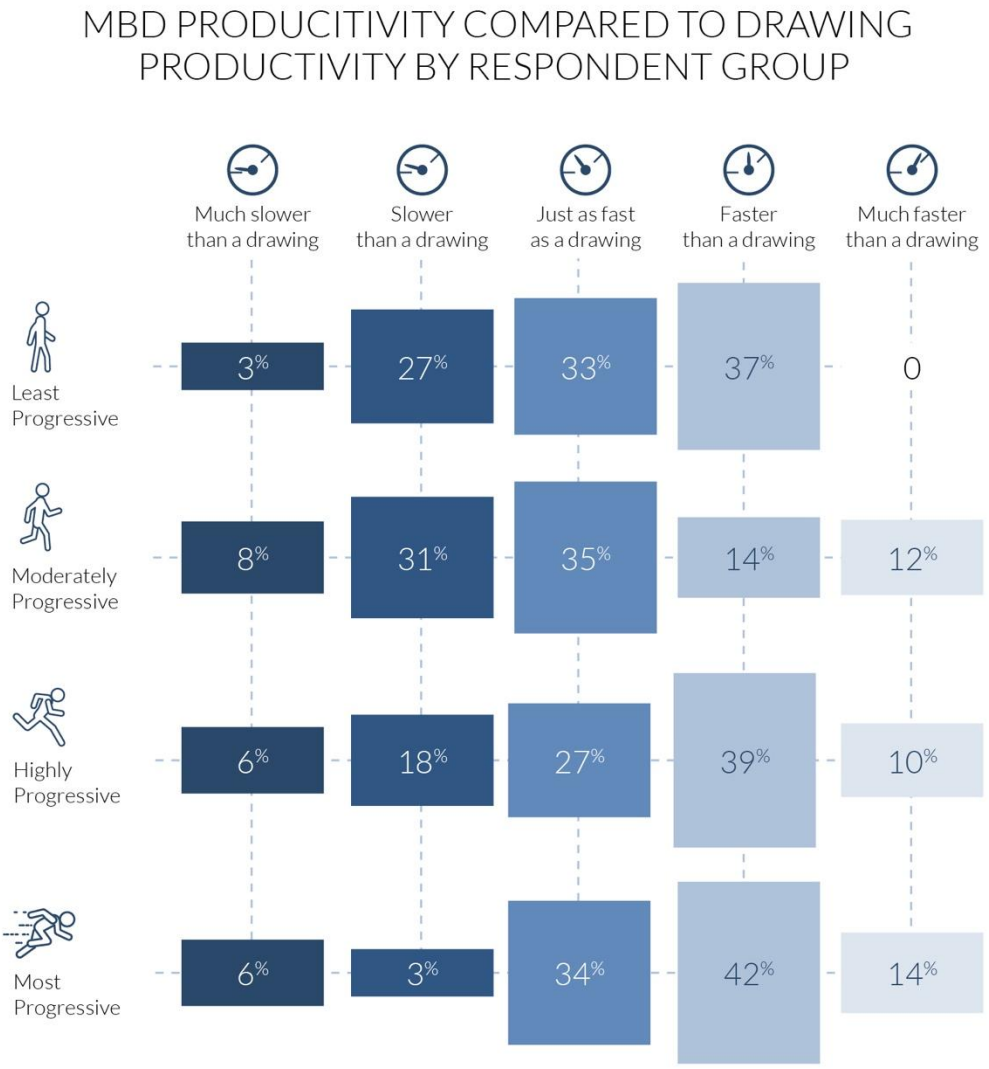


Figure 3: Some 56% of the most progressive create an MBD faster than an equivalent drawing.

This result captured a significant, yet abstract, comparison in how it takes respondents to create design documentation. The study also quantitatively demonstrated how much time, on average, engineers in each of the

different responding organizations spend on design documentation each week.

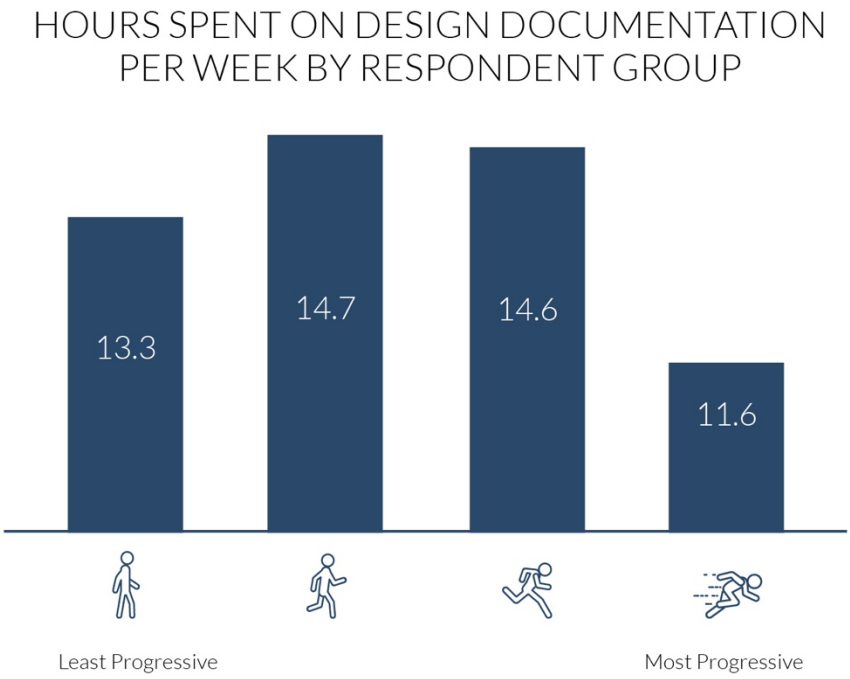


Figure 4: The most progressive spent less time per week on design documentation, an extension of their ability to produce an MBD faster than an equivalent drawing.

The results show, on average, engineers hailing from the most progressive organizations spend roughly two hours *less* on design documentation than those in the least progressive companies, representing a 12% productivity gain. This supports the idea that companies who are more aggressive in the adoption of an MBD strategy, and as a result gain more repetition in the creation of an MBD, can realize significant productivity gains. Practice makes perfect. Or at least, it increases proficiency.

It is important to note, however, that the two middle respondent groups that have adopted an MBD initiative reported they are actually less productive than the least progressive. This gap is due to a difference in the adoption of reduced annotation initiatives. Seventy-three percent of the most progressive have adopted this practice while pursuing an MBD initiative compared to 52% and 29% of the other respondent groups. Such an effort equates to less work when creating design documentation, whether it is a 2D drawing or an MBD.

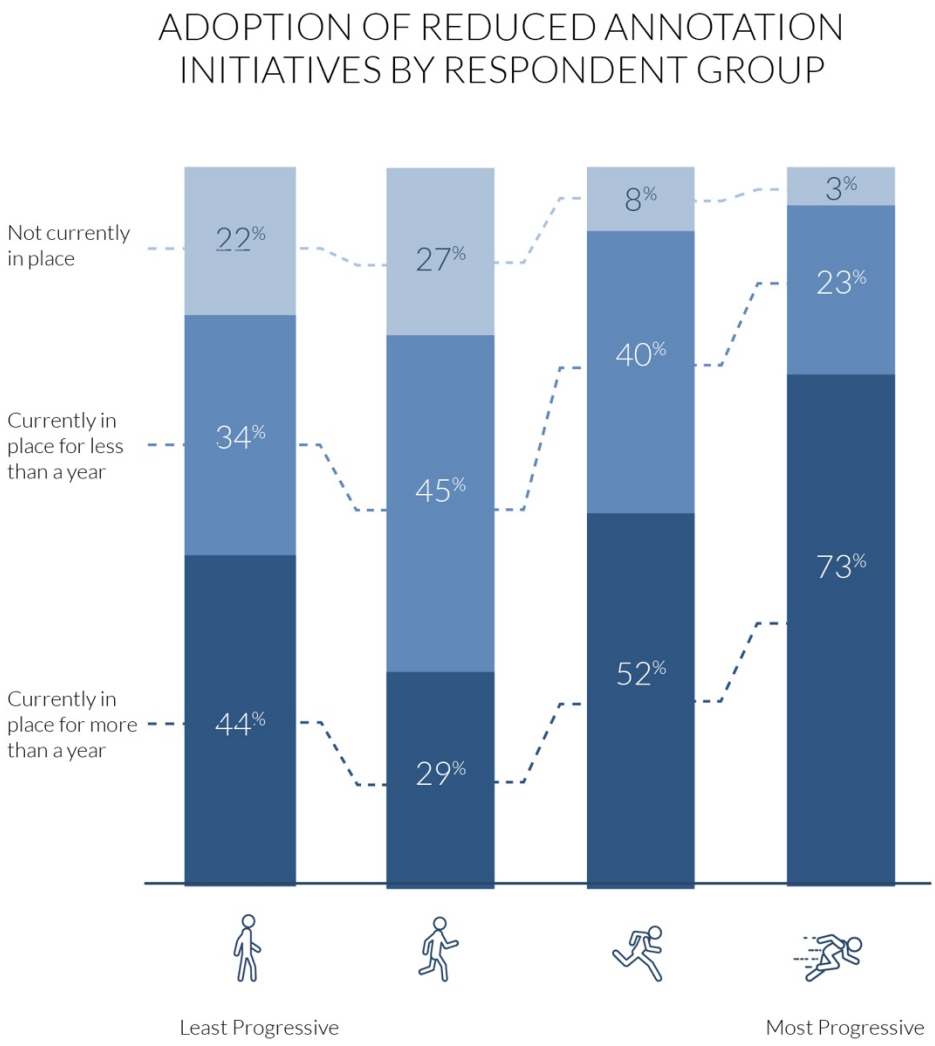


Figure 5: The most progressive pursue reduced annotation initiatives at a high rate alongside their MBD initiatives. There are strong synergies between these two efforts that provide productivity benefits.

When taken together, the results are clear: engineering teams can be more productive when implementing an MBD initiative, resulting in time savings with regards to design documentation. That said, the strongest gains in productivity occur when companies pursue an MBD alongside a reduced annotative initiative.

PRODUCT DEVELOPMENT PERFORMANCE

When a company pursues a product development initiative, they usually do so to increase the rate at which they launch or deliver products on time. The 2020 Model-Based Definition Study investigated product development performance when an MBD is in play and uncovered a number of revealing findings. Organizations in the most progressive group noted they launch or deliver nearly half (48%) of projects on time, roughly the same as the least progressive. Take note. Pursuing an MBD initiative won't translate into faster product launch or delivery.

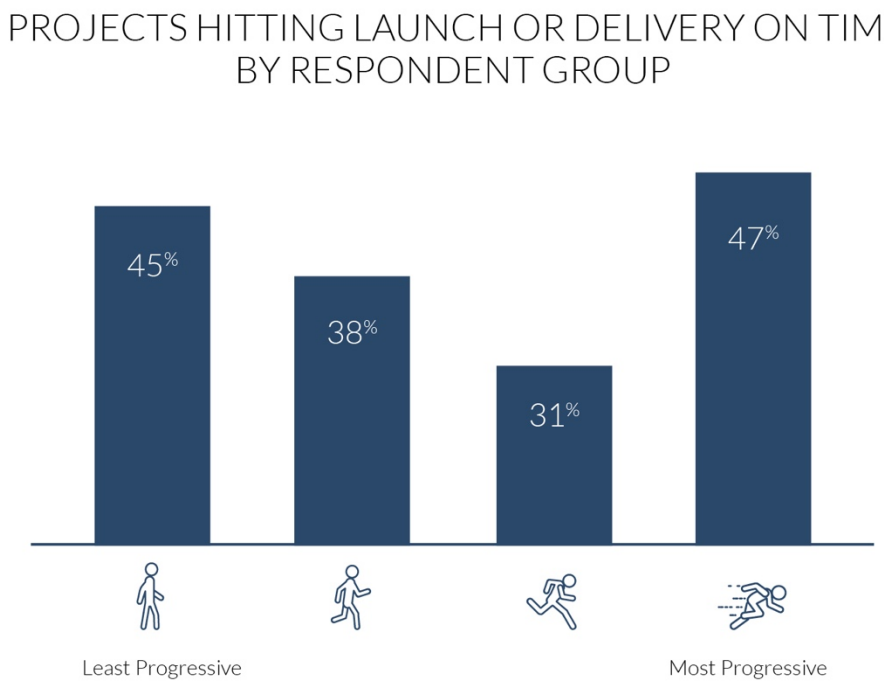


Figure 7: The most progressive are slightly more likely to launch or deliver products on time. The moderately and highly progressive groups hit these milestones at lower rates, mostly due to an absence of model-based practices.

What is most notable is that the two middle groups, the moderately and highly progressive organizations, showed rates that were significantly lower than the most and least progressive. This illustrates the power of repetition and standardization on one type of design documentation. When it is clear and concise, other functional departments can execute their tasks in the product development process more effectively—and more efficiently.

However, when there are no standard documentation practices, organizations run the risk of increasing errors and delays.

The differences seen here can be attributed to how organizations use MBDs. While the moderately, highly, and most progressive organizations all produce MBDs in the design documentation process, not all of these respondents are implementing best practices in MBD use and consumption. The moderately and highly progressive groups are caught in an in-between state where they are developing both an MBD and a traditional 2D drawing. Not only is this an inefficient use of time, but it can result in misinterpretation, confusion, and errors that will continue throughout the rest of the product development process.

EFFICIENCY IN THE DEVELOPMENT PROCESS

Over the course of a product development project, companies can encounter varying difficulties, resulting in nonproductive churn. The 2020 Lifecycle Insights' Model-Based Definition Study quantitatively measured that disruption. Twenty-seven percent of projects developed by both the least and moderately progressive organizations required a surge in resources to hit design release on time, a practice that commonly occurs when a project is behind schedule. This is significant as, when it occurs, engineers are told to drop their current work and assist on the lagging project. Unfortunately, too often, this results in a cyclical effect that can delay other projects as well, leading to yet another surge in resources to keep things on schedule.

The data support the idea that, while the most progressive organizations are hitting product launch or delivery dates at only a slightly higher rate than their least progressive counterparts, they experience less disruption across the product development process. Additionally, the numbers demonstrate that most progressive manufacturers are far more successful than the moderately to highly progressive when it comes to launch and delivery. Committing to an MBD initiative across the entire product development process results in tangible performance benefits.

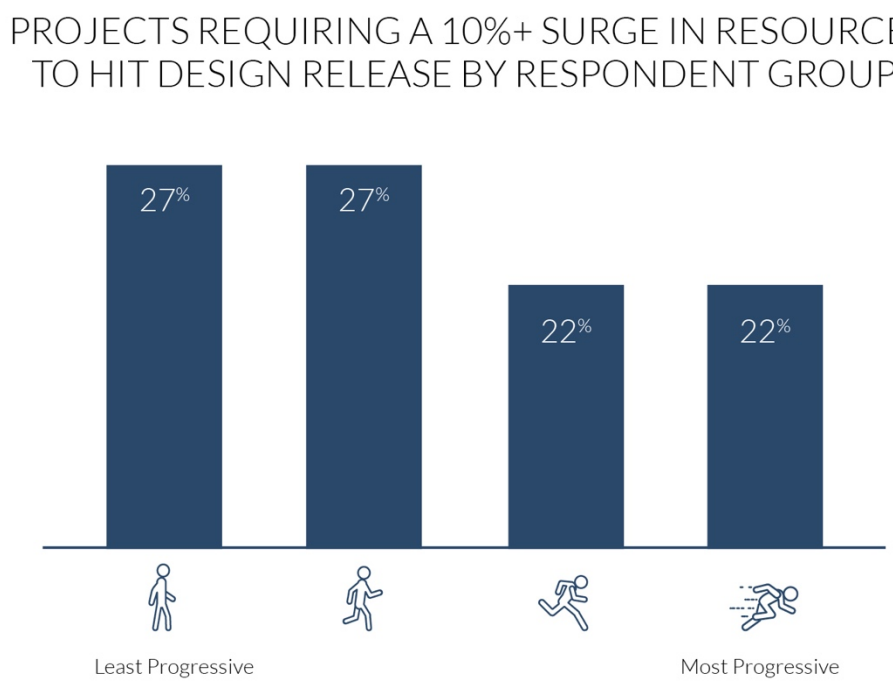


Figure 8: The highly progressive and the most progressive have fewer projects that need emergency engineering resources to finish on time.

TAKEAWAYS ON BENCHMARKING AND PERFORMANCE

Organizations in the most progressive MBD group see significant benefits when it comes to making the most of their development time.

- Respondents in the most progressive group create MBD models much more quickly than traditional drawings. They spend nearly two hours less time on design documentation, representing a 12% productivity gain.
- Respondents in the most progressive group reaped productivity gains not only in engineering, but also in downstream organizations that rely on design documentation.
- Respondents in the most progressive group reported nearly half of their projects launch or deliver on time.



APPLICATIONS OF MODEL-BASED PRACTICES

Findings from Lifecycle Insights' 2020 Model-Based Definition Study demonstrate just how vital the development and consumption of design documentation is to the success of product development. It's no wonder that so many organizations seek improvements in this area. Those in the most progressive MBD group are seeing performance gains as the result of tactical practices, saving significant time and money in the process. Here's how.

USING AN MBD FOR TOLERANCE ANALYSES

Developing a new design isn't as simple as just defining some nominal dimensions. Engineers must define constraints on tolerances to ensure the conformance of components and assemblies. To ensure that designs are within specifications, engineers conduct tolerance analyses to understand how manufacturing variation impacts quality. Traditionally, design documentation specifies what tolerances must be met during production. However, those same documents can also be used as the basis of the analysis.

The study explored this activity by asking survey respondents whether they use MBD as the basis of their tolerance analyses. The results show marked differentiation between the different respondent groups, with 67% of the most progressive stating they have been using MBD for this purpose for more than a year.

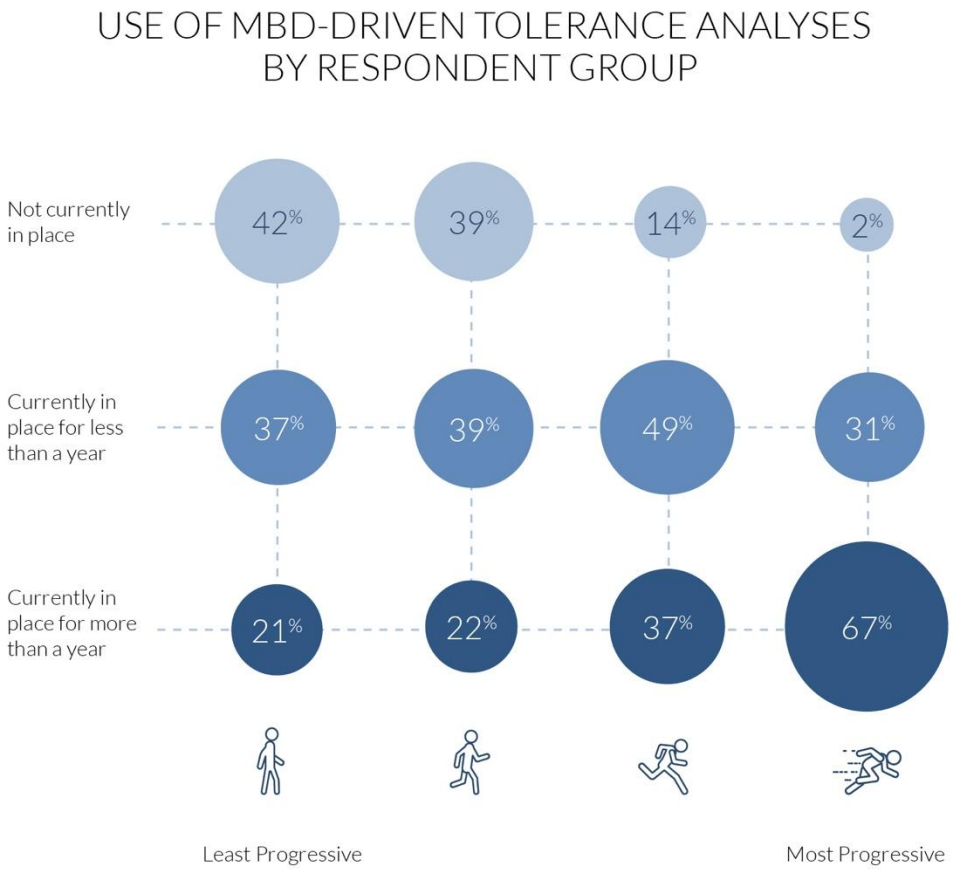


Figure 9: The most progressive employ MBD-driven tolerance analyses than the other groups in the study. Leveraging an MBD reduces the prep time for such analyses, increasing the likelihood they will be done.

Engineers rely on a 2D drawing to conduct traditional tolerance analyses. This requires time to specify tolerances and variations in production, taking up valuable engineering time that could be employed elsewhere. Perhaps it's not a surprise that this important, but not always required, activity is often skipped in lieu of more critical tasks. The result can be a higher-than-expected number of change requests during product development, or a high rate of nonconformances during the production process.

A more progressive MBD approach has significant benefits. When engineers can use an MBD, they can add tolerances as PMI to the 3D model. When engineers add PMI to the MBD documents, they not only document the specifications to which the part must be manufactured, but also set up the complete tolerance analysis for any one component. By defining how components relate to each other in an assembly, engineers can then quickly and easily conduct these important analyses, eliminating excessive change orders and avoidable delays.

The 2020 Model-Based Definition Survey shows that organizations in the most progressive group are employing this process at much higher rates than their members of the other groups. They are not only creating an MBD, but using it for tactical purposes to realize more value throughout the production process.

SHARING AN MBD FOR RFQ PROCESSES

Many companies outsource the production of components and assemblies to supplier partners. To do so, organizations must execute a request-for-quote (RFQ) process in which multiple suppliers bid on the job. The process requires sharing design documentation with those suppliers so they can bid accurately, competitively, and in a timely fashion.

When suppliers lack confidence in the design definition of the component they are bidding to produce and deliver, they tend to increase their pricing to add in a factor of safety. This protects them if they win the job and it's more complex than they initially assessed. It is mutually beneficial for manufacturers to provide suppliers an unambiguous definition for the components.

When asked if organizations share an MBD as part of the RFQ process, 71% of the most progressive organizations stated they had done so for more than a year, compared to 23% of the least progressive group.

Providing potential suppliers with an MBD instead of a 2D drawing of the component or assembly decreases the risk that the supplier will misinterpret the requirements. It also limits the potential that those suppliers will request additional information while building out the bid, leading to delays in the process.

When organizations share the less ambiguous MBD, suppliers can spin, pan, and zoom into the 3D model. The supplier can further interrogate the model as needed to better understand its measurements and physical characteristics. As a result, both manufacturers and suppliers can have greater confidence in accurate and timely bids.

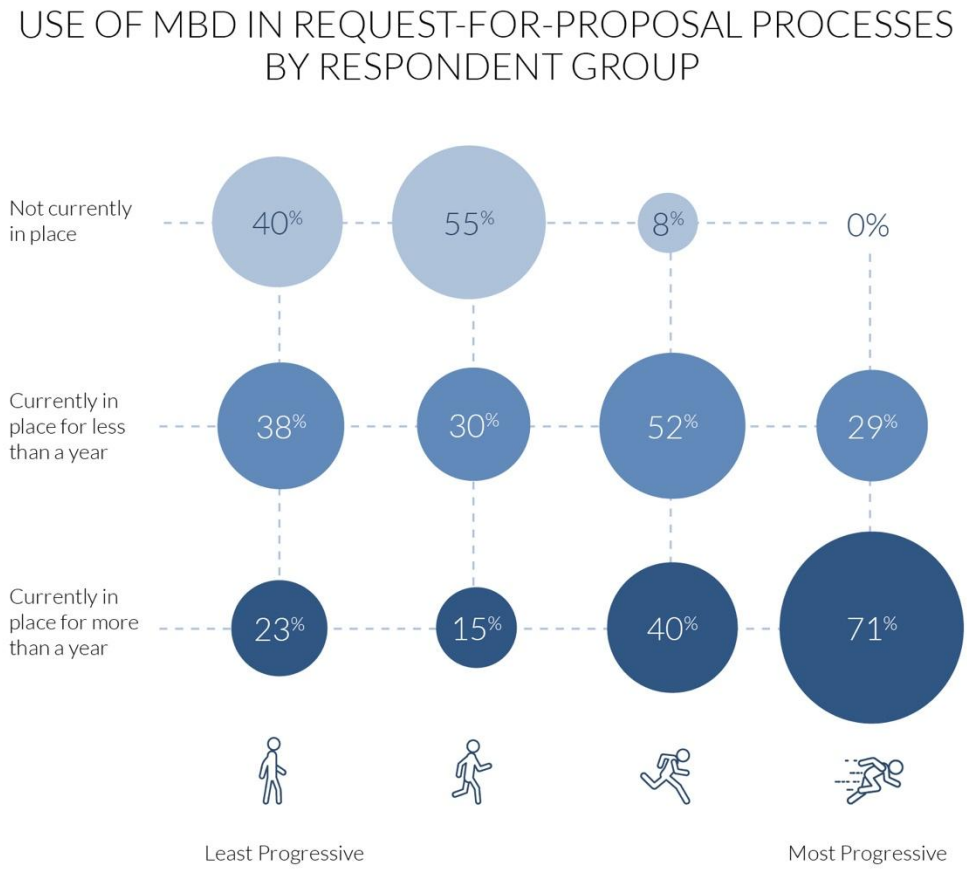


Figure 10: The most progressive utilize an MBD in their request-for-proposal processes at higher rates. Sharing a less ambiguous MBD allows suppliers to bid with more confidence and thus more aggressively.

LEVERAGING AN MBD FOR MACHINING

Manufacturing relies significantly on machining, either for tooling or for components. Modern machining relies on computer numerical controlled (CNC) tool paths to drive the feeds, speeds, and other parameters in any machining operations.

Manufacturing organizations develop their tool paths in different ways. Some try to do so quickly to start production as soon as possible. Others take more time to avoid errors that could later break machine tools due to clashes with the component being produced or damaged production equipment.

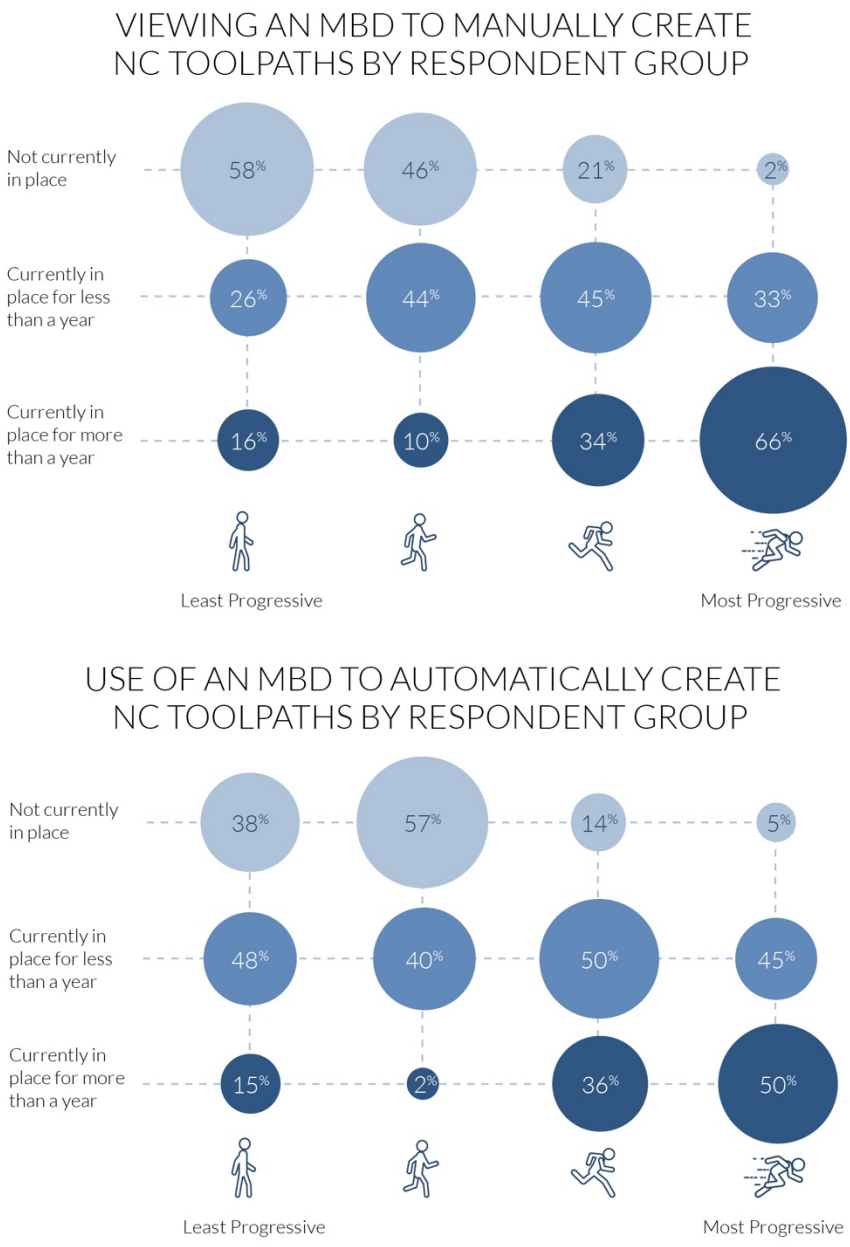


Figure 11: The most progressive are more likely to use an MBD to create machining toolpaths, either by viewing them or by leveraging semantic PMI for toolpath automation.

As high-speed machining has become more mainstream, many organizations now strive to standardize tool path creation based on manufacturing best practice, standard feeds, speeds, and other predefined parameters that achieve specific surface finishes and tolerances. This is yet another area where an MBD can help.

Sixty-six percent of survey respondents in the most progressive group stated they use their MBD to produce machining tool paths, with 50% of that same group noting they use the MBD to automate such tool paths.

Traditionally, machinists rely on a printed hard copy of a 2D drawing, noting the tolerances and other PMI, to enter in the tool path for the component manually. This is a slow and cumbersome process. Manual input can undermine the use of standards in the machining process as well as potentially introduce human error. Too often, such issues result in delays to the start of production, as well as scrap and rework on the shop floor.

When machinists can use an MBD instead of the traditional drawing, they have a less ambiguous blueprint from which to work. This reduces the chance of misinterpretation as well as downstream costs and delays in the machining process. In fact, when using computer-aided manufacturing applications to read the MBD's PMI, applications can then automatically generate the tool parts needed to machine product components, while applying standards and best practices. This can accelerate the development of tool paths and encourage the use of best practices more widely across all steps in the product development process.

EMPLOYING AN MBD FOR QUALITY ASSURANCE

After components are produced, quality assurance (QA) teams must verify that the parts comply with the constraints outlined in the accompanying design documentation. QA teams use both contact- and non-contact-based methods to do this critical job, including the use of coordinate measuring machines (CMM) and laser scanners. The survey showed that some of the most progressive respondents are using MBD models to determine quality quickly and accurately, and even to develop the towpath for the CMM machine probe to check tolerances.

Specifically, 67% in the most progressive group viewed an MBD while manually producing CMM toolpaths, while 50% relied on the model to automatically generate them. This is in stark contrast with the least progressive group, where 16% and 17% reported the same, respectively.

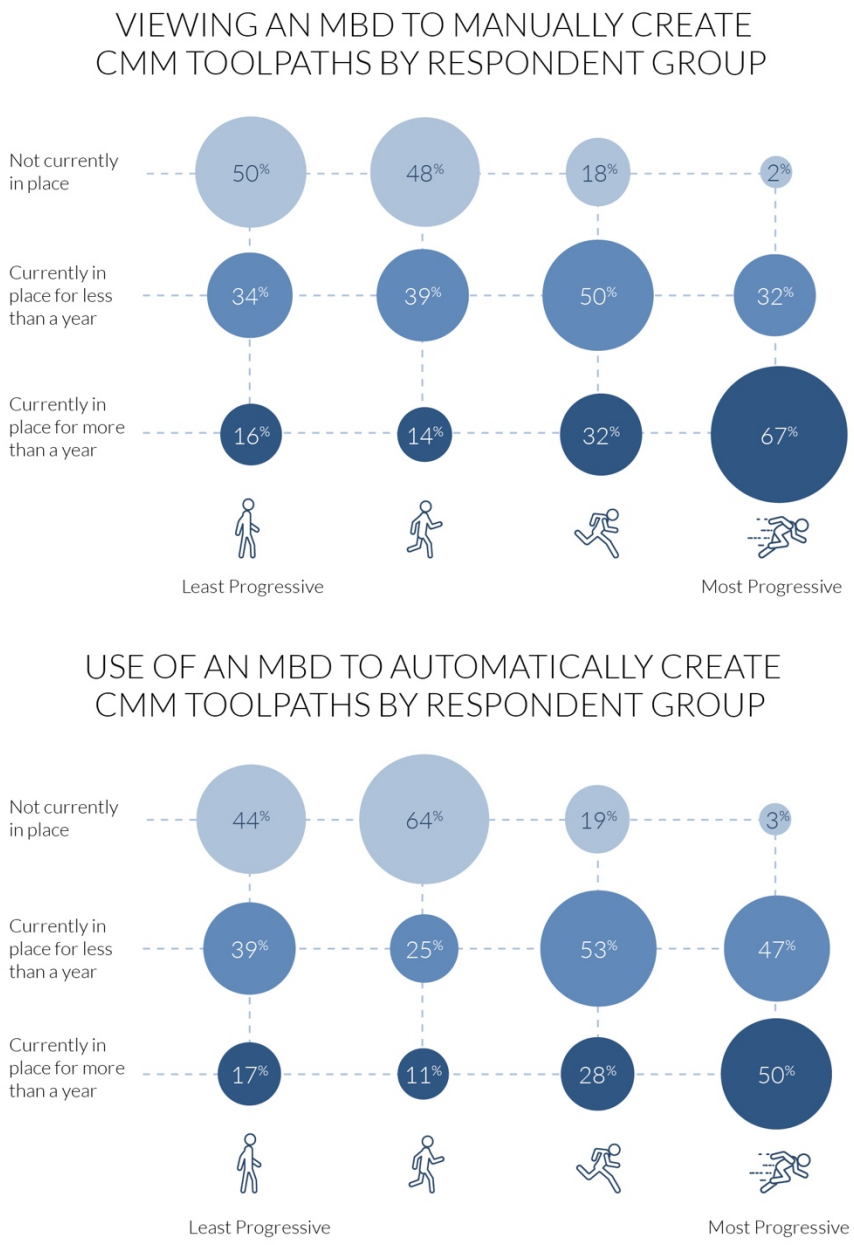


Figure 12: The most progressive are more likely to develop CMM toolpaths utilizing an MBD, either by viewing them or leveraging semantic PMI for automation.

Specifically, 67% in the most progressive group viewed an MBD while manually producing CMM toolpaths, while 50% relied on the model to automatically generate them. This is in stark contrast with the least progressive group, where 16% and 17% reported the same, respectively.

By foregoing traditional approaches relying on the interpretation of a printed hard copy 2D drawing—a process that is both slow and prone to error—the most progressive organizations are using MBD to avoid damaged probes and equipment for CMM programming.

In addition, this most progressive approach allows manufacturers to directly read an MBD's PMI to develop inspection tool paths for CMM machines automatically. Taking this sort of automated approach leads to both time and resource savings.

USING AN MBD FOR INSTRUCTIONS

Another set of deliverables that are developed along with any new product are instructions, including manufacturing and assembly sequences, quality inspection steps, and service procedures. They also likely include a variety of technical documentation and information for owners' manuals. Manufacturing organizations want to develop high quality, accurate, and useful instructions in a short amount of time.

Once again, the results from the Lifecycle Insights 2020 Model-Based Definition Study show that MBDs can improve this endeavor. Seventy-three percent of the most progressive respondents said they use MBD models to inform manufacturing instructions, compared to 37% in the least progressive group. The study illuminated similar trends in service instructions (62% compared to 25%).

Typically, instruction authors use a combination of 2D drawings and 3D models to develop the figures used in this important documentation. To come up with useful and accurate information, authors must accurately interpret design specifications. If they aren't equipped to do this, errors can result.

Instruction authors who use an MBD and its embedded PMI gain a distinct advantage. They can view, spin, zoom, and pan the 3D model to better understand its characteristics and use. Authors also do not need to reference other documentation—which may require specific knowledge and expertise for interpretation—as they write the appropriate instructions. Once again, the MBD offers unparalleled savings in an author's time and in later error correction.

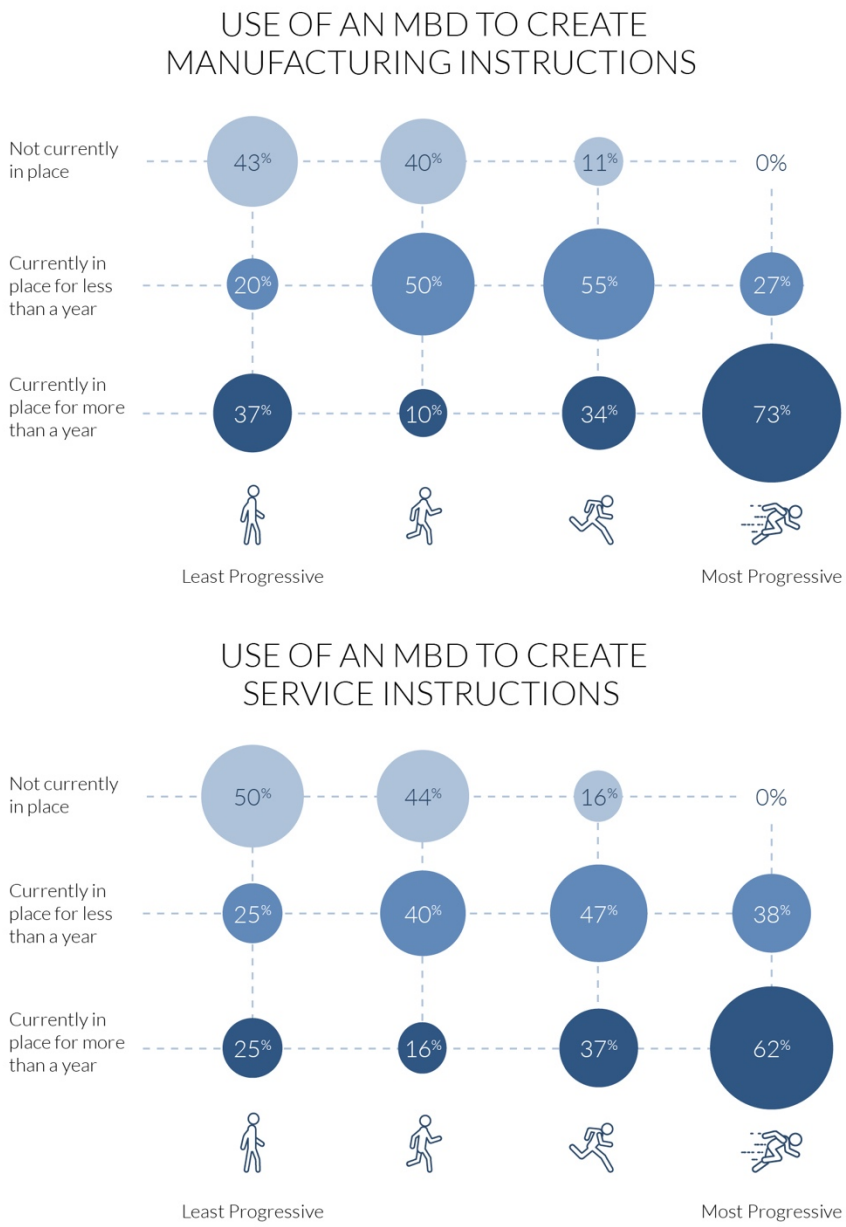


Figure 13: The most progressive are more likely to use an MBD to create manufacturing or service instructions. The PMI in an MBD provides more detail that allows technical publication authors to independently develop their deliverables.



SUMMARY AND RECOMMENDATIONS

In the effort to produce more in less time, executives are prioritizing the improvement of design documentation to govern the entire product development progress. Today, many are using MBD initiatives as part of that effort. But the benefits they reap from these initiatives may vary, depending on how, where, and when they use an MBD.

To date, few companies have adopted model-based design practices throughout the development process. Those who have, however, are realizing marked performance advantages in comparison to more slowly adopting peers. Analysis from the Lifecycle Insights' 2020 Model-Based Definition Study clearly demonstrates the following:

- The top goal for more than 50% of study respondents was to accelerate their time-to-market. The desire to avoid downstream development delays and associated costs was also high on the list, with 51% selecting this objective as one of their top three. One-third of study participants hope their improvement efforts will help to address the industry trend of growing product complexity.
- Engineers at organizations that develop an MBD instead of a drawing show a 12% productivity gain in time spent on design documentation. These organizations are also interested in improvements to facilitate additional cost and resource savings.

- Organizations in the most progressive group showed slight improvements in product development performance over the least progressive. Notably, the moderately and highly progressive groups were much further behind, suggesting the importance of committing to a single design documentation process to avoid errors and delays.
- Seventy-one percent of the most progressive organizations have been using MBDs for tolerance analyses for at least one year.
- Sixty-six percent of the same group are using MBDs to help produce machining tool paths. One-half of the same group is harnessing the models to automate this process.
- Sixty-seven percent of the most progressive manufacturers rely on MBDs to manually produce CMM toolpaths. And 50% of this respondent group leverages MBDs for automated processes.
- Organizations also use MBDs to produce quality instructions. Seventy-three percent have found success using MBDs to inform manufacturing instructions, while 62% refer to these models for service instructions.

Based on these findings, Lifecycle Insights recommends:

- Investigating MBD initiatives to improve engineering productivity while maintaining other important business metrics.
- Adopting reduced annotation initiatives alongside MBD initiatives.
- Moving away from drawing-based practices and pursuing model-based practices throughout the company to get the most value from creating an MBD.



Chad Jackson leads Lifecycle Insights' research and thought leadership programs, attends and speaks at industry events, and reviews emerging technology solutions.

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