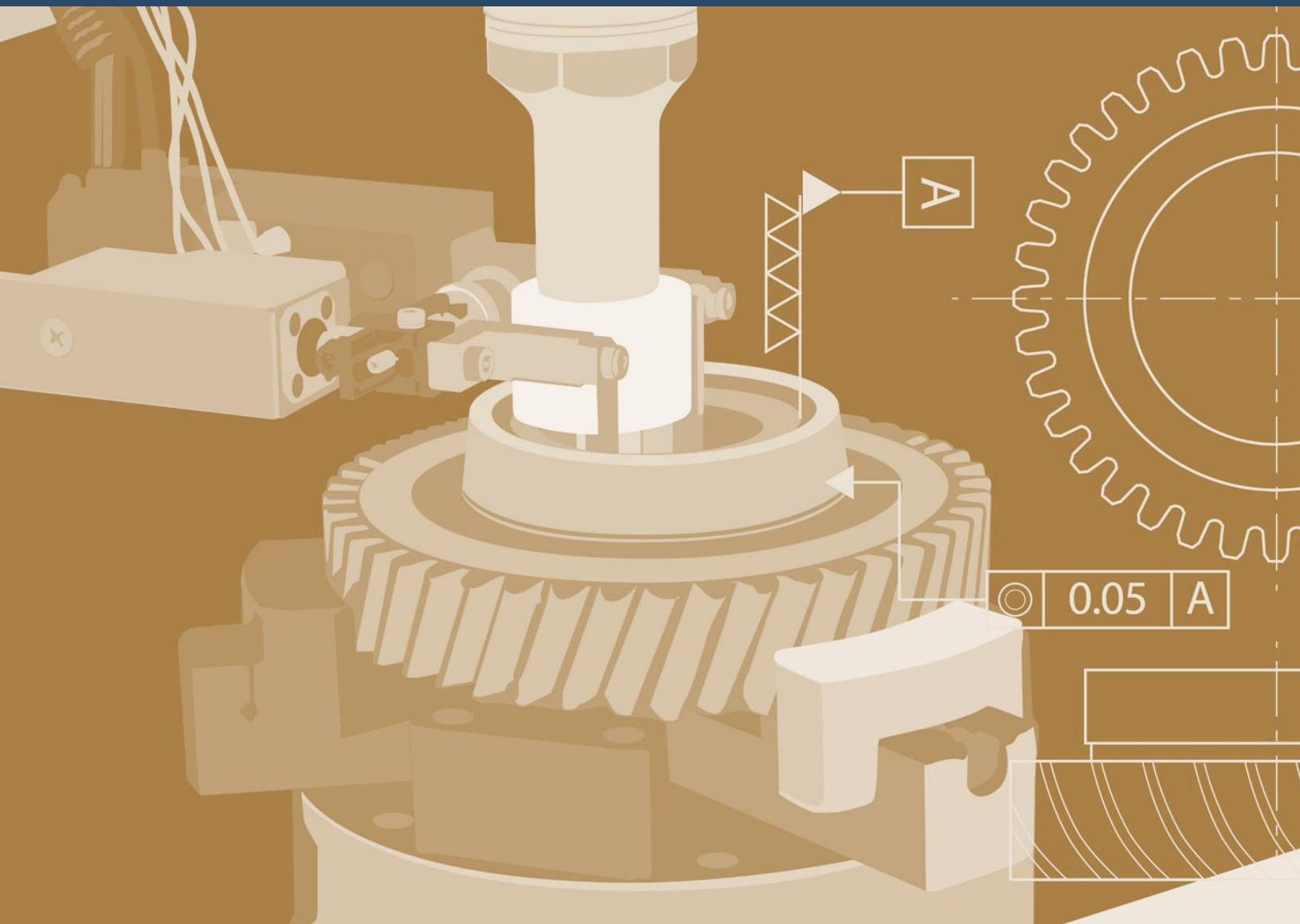
THE TACTICAL GUIDE TO DEPLOYING MBE INITIATIVES

LIFECYCLE INSIGHTS



EXECUTIVE OVERVIEW

Times are changing for Model-Based Enterprise (MBE) initiatives. More executives are recognizing the value in using a Model-Based Definition (MBD) instead of a 2D Drawing. However, identifying the best way to switch is not easy. Each functional department uses design documentation in different ways. Depending on which department transitions first, the plan for adoption will vary dramatically. But just as importantly, how an organization deploys such an initiative matters greatly. Organizations must start small, allowing engineering to make the transition, and then enabling one functional department to start receiving that deliverable. From there, it builds synergistic value with each expansion.

Providing guidance on navigating the transition from 2D Drawing reliant organization to a Model-Based Enterprise one is the purpose of this report. It presents specific guidance in different sections.

Guidance by Functional Department offers department-specific advice for engineering, procurement, tooling design, machining, and quality organizations.

Managing Cultural Change provides more generic advice on navigating the cultural change that comes with any technology-led initiative, including an MBE one.

Summary and Recommendations recaps the findings and conclusions from the report and offers specific guidance as next steps.

This report provides guidance on planning and deploying a Model-Based Enterprise initiative.

An MBE initiative promises great benefits for companies looking to boost engineering productivity while reducing scrap and waste. This report accelerates a company's education on how to adopt an MBE initiative and realize those benefits faster with less disruption.

TABLE OF CONTENTS

EXECUTIVE OVERVIEW 2

GUIDANCE BY FUNCTIONAL DEPARTMENT 5

- THE TRANSITION FOR ENGINEERING 5
- THE TRANSITION FOR PROCUREMENT 8
- THE TRANSITION FOR TOOLING DESIGN 10
- THE TRANSITION FOR MACHINING 13
- THE TRANSITION FOR QUALITY 15

MANAGING CULTURAL CHANGE 18

- LONG-TERM VISION, SHORT-TERM STAGES 18
- AVOID MANDATES, SHARE OWNERSHIP 19
- PREPARING FOR TOUGH DECISIONS: INITIATIVE VS. PRODUCTIVITY 20
- INVEST IN PROGRESSIVE TRAINING 21

SUMMARY AND RECOMMENDATIONS 23

- SUMMARY 23
- RECOMMENDATIONS 25

GUIDANCE BY FUNCTIONAL DEPARTMENT

A company's transition from a drawing-reliant one to a MBE has many paths and stages. The first step is straightforward: engineering shifts from producing a 2D drawing to generating an MBD. After that, companies release an MBD to one of several functional departments: procurement, tooling design, machining, quality, or technical documentation. Once they have achieved success, they move on to the next logical choice for their circumstances. This section provides guidance on how each functional department makes the change from 2D drawings to an MBD.

This section details the stages of adoption of an MBE initiative for engineering, procurement, tooling design, machining, and quality departments. It also describes the interaction between departments in an MBE initiative.

THE TRANSITION FOR ENGINEERING

When assessing the transition of an engineering organization from producing a 2D drawing to an MBD, it is important to keep the original purpose of design documentation in mind. Engineers create design documentation to:

- Convey the complete and detailed geometric form of a component,
- Define the measurements and thresholds within which a component meets quality standards,
- Allow other functional departments to create derived deliverables.

Traditionally, companies use 2D drawings to fulfill all three of these functions. Today, however, modern Computer-Aided Design (CAD) applications define design geometry to exceedingly accurate measures. As such, dimensions are not needed *convey the complete and*

detailed geometric form of a component: the geometry inherent definition does this alone. Creating dimensions to nominally locate a design's spatial location is duplicative work: a non-value added task. That, in turn, frees engineers up to dedicate more time to design instead of documentation.

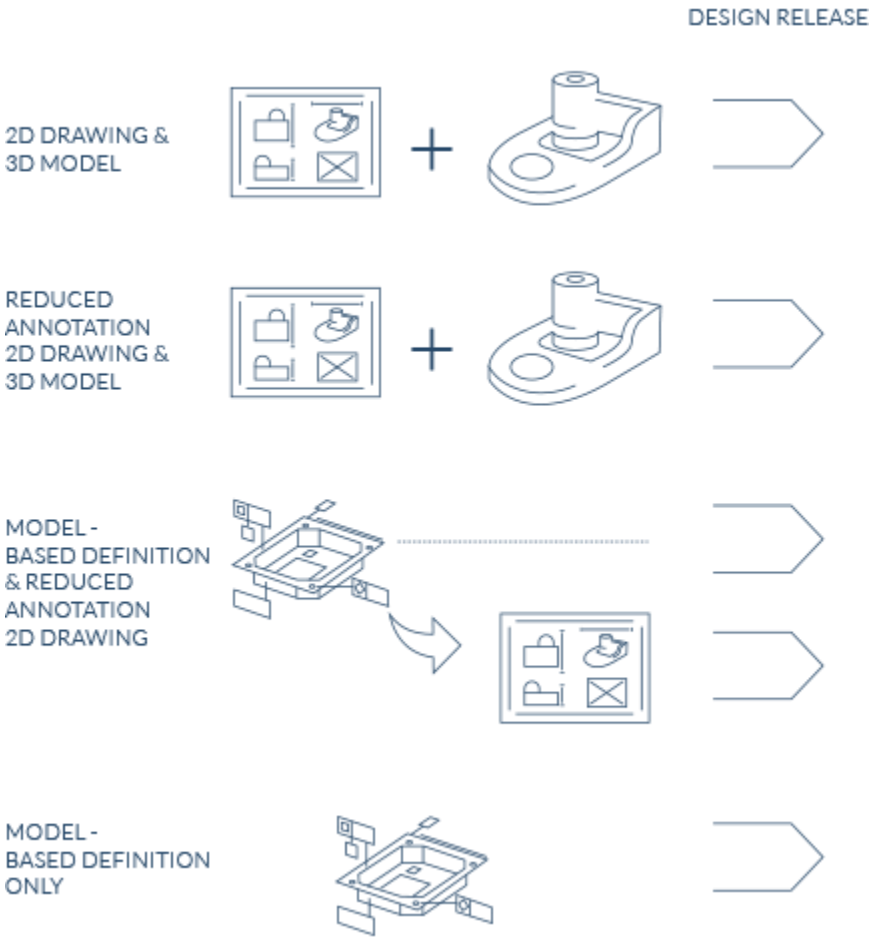


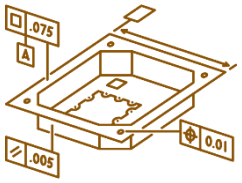
Figure 1: Stages in Engineering's Transition During an MBE Initiative

Engineering's transition during an MBE initiative is composed of many steps. Note, however, that even as engineering shifts all the way to releasing an MBD, they will still need to also release 2D drawings for a number of functional departments and the supply chain. It is critical to turn to the automated creating of a 2D Drawing from an MBD during the progression of an initiative.

The first change in a company's transition is not to switch design documentation from a 2D drawing to an MBD. Instead, it is shifting the function of a dimension. The purpose of a dimension changes from *conveying the complete and detailed geometric form of a component* exclusively to *defining the measures and thresholds within which a component meets quality standards*. Dimensions

are no longer used to spatially locate geometry. They are only used to define what is measured in quality assurance functions after parts are manufactured and products are assembled. This is called a Reduced Annotation effort. Adopting a Reduced Annotation effort does not require the use of an MBD. It applies equally to 2D drawings. This shift trains engineers and the rest of the company to view the geometry and dimensions of drawings very differently without changing the deliverable.

Once a company has adopted a Reduced Annotation approach, then engineering transitions to create and release an MBD instead of a 2D Drawing. During this shift, engineers add Product and Manufacturing Information (PMI) directly to a 3D model instead of the 2D Drawing. Additionally, the only PMI included *defines the measures and thresholds within which a component meets quality standards*, not *conveys the complete and detailed geometric form of a component*.



The shift from a 2D Drawing through a Reduced Annotation effort and to an MBD promises significant productivity gains for engineering.

As noted earlier, the transition to becoming a Model-Based Enterprise is progressive. This means not every functional organization will start using an MBD immediately; some will continue to use 2D Drawings. During that time, engineering must deliver both an MBD and a 2D Drawing for released designs. Documentation automation capabilities of CAD software allows engineering to avoid the duplicative work of creating both an MBD and a 2D Drawing.

Overall, the transition for engineering involves multiple steps.

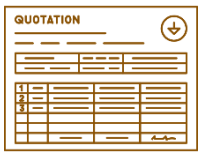
- Engineering adopt a Reduced Annotation effort for 2D Drawings as a first step. This focuses on changing the function of dimensions from *conveying the complete and detailed geometric form of a component* exclusively to *defining the measures and thresholds within which a component meets quality standards*. This requires some technical training.

- Once engineering has adopted a Reduced Annotation effort, they pursue the transition from creating and releasing a 2D Drawing to doing so with an MBD. This step will require some technical training and reinforcement through well-defined processes. Engineering must deliver 2D Drawings to some of the functional departments in the company. Documentation automation capabilities of CAD software is crucial to avoid the duplicative work of creating both an MBD and a 2D Drawing.

THE TRANSITION FOR PROCUREMENT

In procurement, procurement agents provide design documentation in a Technical Data Package (TDP) to prospective suppliers as part of the Request-for-Quote (RFQ) process. Participating suppliers use those deliverables in their Cost, Price, and Quote (CPQ) process, submitting a proposal bid back to the procurement agent. If the supplier is awarded the project, the design documentation acts as part of the legal contract between the companies, specifying quality measures as acceptance criteria.

There are adjustments for procurement agents. They will need some familiarization with technical capabilities to open, view, and interrogate an MBD independently. This primarily involves training and use) For procurement, engineering's transition through a Reduced Annotation effort and arriving at the creation and release of an MBD is easily managed: it is just another file to include in the Technical Data Package (TDP). However, there are challenges from a process and cultural perspective. Companies often have little insight into the readiness of their suppliers to accept a Reduced Annotation 2D Drawing or an MBD. Many are reticent to incorporate these changes into their RFQ processes as a result.



The transition for procurement focuses on getting suppliers to use an MBD for proposal response and, once the contract is awarded, all other processes including tooling design, machining, quality, and more.

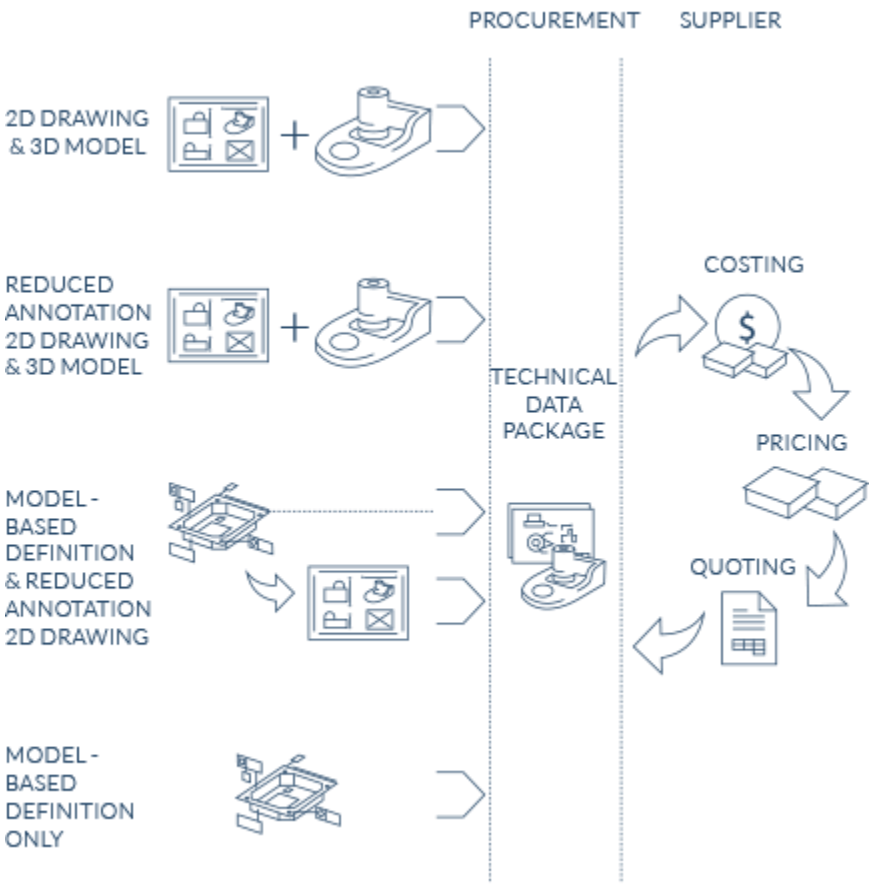


Figure 2: Stages in Procurement's Transition During an MBE Initiative

The best way to gain clarity into the readiness of a company's supply base is to conduct survey-based research. Such studies must capture three different assessments of suppliers regarding their use of design deliverables, including a 2D Drawings, a 3D Model, and an MBD, in costing, pricing, and quoting as part of the RFQ process.

1. Assessment of the supplier's current operating state, providing insight into how suppliers are running their CPQ processes.
2. Assessment of the supplier's current capability state, providing insight into the supplier's training, skills, and technology to accept new deliverable types such as an MBD.

Survey-based assessments of supplier's adoption of an MBE initiative should include current operating state, current capability state, and future operating state.

3. Assessment of the supplier's future plans, providing insight into supplier's intent to make changes to their CPQ processes with respect to new deliverable types such as an MBD.

Armed with this information, procurement agents and executives develop detailed plans to help suppliers move from their current operating state to one more aligned with the MBE initiative. This includes training, process consultation, and software acquisition.

In all, the transition for procurement involves multiple steps.

- Training must be provided for procurement agents to open, view, and interrogate an MBD. They, and IT staff, must incorporate an MBD into the TDPs to extend MBE initiatives into the supply chain.
- Conducting a survey-based study is a good way to gain insight into the current operating state, the current capability state, and the future plans of a company's supply base. Insight gained from such studies allow executives to build out more detailed plans to facilitate the supplier's transition towards an MBE initiative.

Getting suppliers to transition to an MBD-based process is very similar to the effort to transition internal functional departments. The guidance in section three, Managing Cultural Change, applies equally to suppliers.

THE TRANSITION FOR TOOLING DESIGN

Companies develop jigs, fixtures, molds, dies, and other tooling for use in the manufacture of components and products. Tool designers use design documentation as an input to their engineering activities. In many cases, such tooling must tightly conform to the organic shapes of modern products while keeping manufacturing variation within specifications.

Many of today's tool design departments are mature in their use of 3D models. They utilize such designs in the development of their tooling models, such as when they remove the design volume out of a block representing tool steel to ensure a tight fit. This lets tool designers *convey the complete and detailed geometric form of a*

component. Tool designers, however, rarely use 3D models from engineering alone. They refer to released 2D Drawings to *define the measures and thresholds within which a component meets quality standards*. This, in turn, drives the dimensions, tolerances, and other annotations that specify the measurements and thresholds within which the tooling meets quality standards.

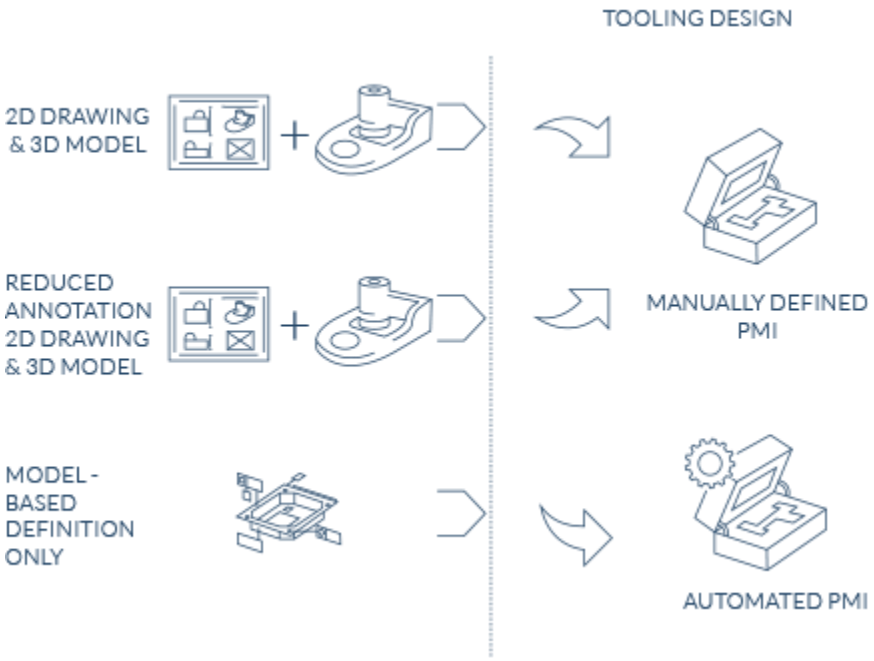


Figure 3: Stages in Tool Design's Transition During an MBE Initiative

As engineering shifts through the Reduced Annotation effort, tooling designs must adjust. Remember that nominal dimensions will not be included in the 2D Drawings. Given that, they need a means to open, view, and most importantly, interrogate the reduced annotation 2D Drawings so they take their own measurements. The 2D Drawings will still include tolerancing and other annotations that tooling designers use to develop their own tooling model.

Engineering's arrival at the creation and release of an MBD requires another change for tool designers. Instead of opening, viewing, and interrogating a 2D Drawing, they reference the MBD. This represents a consolidation

The transition for tooling design is a small shift from focusing on the 3D model and a 2D Drawing to the use of an MBD.

of the definition to *convey the complete and detailed geometric form of a component*, traditionally the 3D Model, and the means to *define the measurements and thresholds within which a component meets quality standards*, traditionally the 2D Drawing, to the MBD. Essentially, the tooling designer references the MBD instead of the 2D Drawing.

The most advanced step in using an MBD in tooling design relies on semantic, or machine-readable, PMI. Progressive Computer-Aided Manufacturing (CAM) applications read this form of tolerance and other annotation information to automate the generation of machining toolpaths and quality inspections. With this available in an MBD, tooling designers associate or transfer semantic or machine-readable PMI from the design 3D model to the tooling model. The machine-readable PMI in the tooling model is then used for automation later in development.

The most advanced stage of MBE adoption in tooling design is automating the transfer of PMI from an engineering MBD to the tooling design. Machining can then use that PMI for machined parts as well as tooling.

In summary, the transition for tooling design involves three distinct steps.

- As engineering shifts to a Reduced Annotation effort, tooling designers need training to open, view, and interrogate the reduced annotation 2D Drawings.
- When an MBD is released from engineering, tooling designers need more training to work with the new deliverable. They consolidate their efforts of working with a 3D Model and a 2D Drawing to an MBD.
- Tooling designers associate or transfer machine-readable PMI from an MBD produced by engineering to their tooling model to automate activities in machining or quality inspections. They will need more training to properly use this capability.

THE TRANSITION FOR MACHINING

Another functional department that frequently uses design documentation is the group that develops machining toolpaths in manufacturing. Machinists reference design documentation as one of the most critical inputs to their activities. Nominal and tolerance information drives many the machining strategies, combinations of different toolpaths of varying feeds and speeds, to produce final parts that conform to quality specifications.

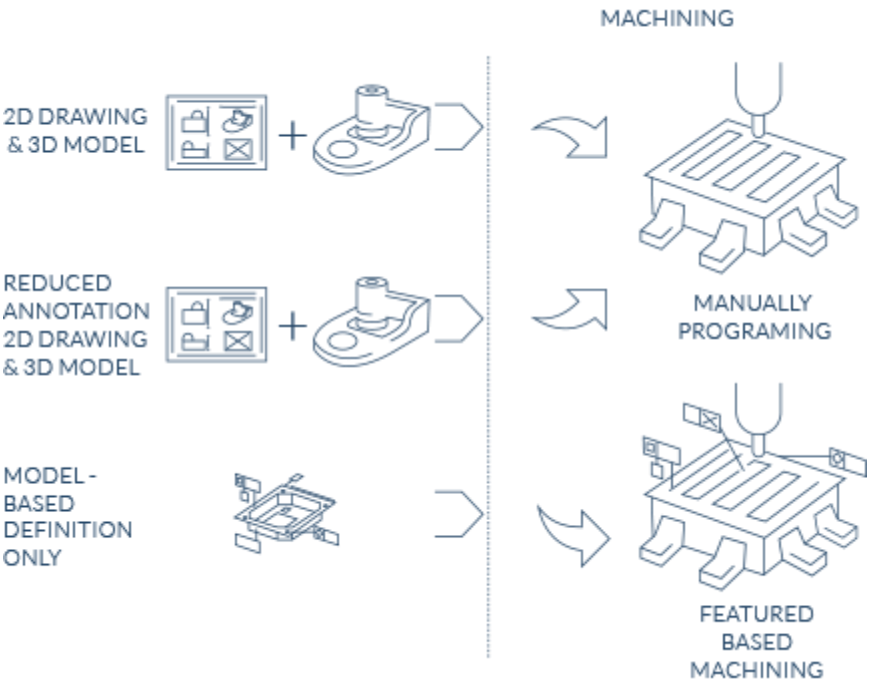
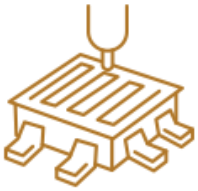


Figure 4: Stages in NC Programming's Transition During an MBE Initiative

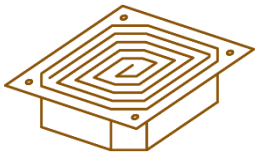
Like tooling design, today's machinists are mature in their use of 3D Models. Progressive CAM applications generate toolpaths that directly follow design geometry embedded in machining models. Those 3D models are used as the definition to *convey the complete and detailed geometric form of a component*. However, machinists look at 2D Drawings to *define the measurements and thresholds within which a component meets quality standards* to set machining parameters and select tools.



The first stage in the transition for machining involves the progressive acceptance of 2D Drawings to reduced annotated engineering documentation and then an MBD. With all three, NC programmers adjust the feeds and speeds of toolpaths manually. They simply view and interpret different deliverables.

For machinists, engineering's transition to a Reduced Annotation effort requires an adjustment. Nominal dimensions are not included on the reduced annotation 2D Drawings. Machinists will need training to open, view, and interrogate the new deliverable to take nominal measurements. The 2D Drawings will still include tolerancing and other annotations. It is viewed for that purpose.

The use of an MBD in generating machining toolpaths implies broader changes for machinists. As was the case with tooling design, this represents a consolidation of the definition to *convey the complete and detailed geometric form of a component*, traditionally the 3D Model, and the means to *define the measurements and thresholds within which a component meets quality standards*, traditionally the 2D Drawing, to the MBD. The methods to measure nominal dimensions does not change dramatically from a reduced annotated 2D Drawing to an MBD. Likewise, the MBD displays tolerancing and other annotation information required to set speeds and feeds.



The transition to using an MBD to generate NC toolpaths presents significant automation opportunities through feature-based machining. This shift presents an opportunity accelerate the generation of NC toolpaths. However, the greater value lies in standardization of best machining practices.

The last progression for machinists in the use of an MBD lies in machine-readable PMI and the automated creation of toolpaths in a capability called Feature-Based Machining (FBM). Progressive CAM applications recognize the parametric value of a PMI annotation, such as a surface finish, and the geometric surface to which it is attached (continue this example). With that information, the CAM application automatically generates a set of toolpaths based on standards and templates defined by the machinist. The software essentially applies a predetermined machining strategy to the machining model based on the PMI of an MBD. Leveraging this approach requires defining these machining strategies, standards, templates, and associated feed parameters, speed parameters, and tool selections. This work must be done upfront by the machinists. Furthermore, additional training is required for the machinists to perform the setup and to apply this new functionality.

Overall, the transition for machinists involves three distinct steps.

- Machinists need training to open, view, and interrogate the reduced annotation 2D Drawings as engineering shifts to a Reduced Annotation effort.
- Machinists need more training to work with the new deliverable when an MBD is released from engineering. They consolidate their efforts of working with a 3D Model and a 2D Drawing to an MBD.
- Machinists leverage machine-readable PMI in an MBD to automatically apply machining strategies to generate sets of toolpaths. They will need more training to set up and apply this capability.

THE TRANSITION FOR QUALITY

The use of design documentation by the quality assurance department varies depending on their practices and technologies. Invariably, design documentation is used to *define the measurements and thresholds within which a component meets quality standards*.

- Those leveraging manual inspection approaches have inspectors review these deliverables as they inspect components and products.
- Those using Coordinate Measuring Machines (CMM) use design documentation to identify locations for measurements and automate the creation of inspection toolpaths.
- Those using 3D scanning as an inspection method compare point cloud data to the engineering's 3D model.

Today, some quality departments rely heavily on manual processes. With this approach, they review design documentation while manually taking physical measurements off components and products or inspectors program CMM machines manually.

There are many different applications of an MBD to quality. This includes the use of an MBD when programming CMM equipment for planning. It also includes the use of an MBE when manually entering a bill of characteristics or comparing CMM measurements or 3D scans to an MBD.

Some companies are more mature in their use of a 3D model. Such deliverables are used to automate the creation of touch points for CMM machines. Likewise, 3D scans are overlaid on top of 3D models to show the spatial differences between the two. In either case, inspectors manually review design documentation to check if the measurements are in or out of specification.

Many quality departments use 3D models today to program touch points for CMM measurements. The transition for these organizations is simpler: they must simply leverage PMI in an MBD to determine if that measurement is in or out of conformance.

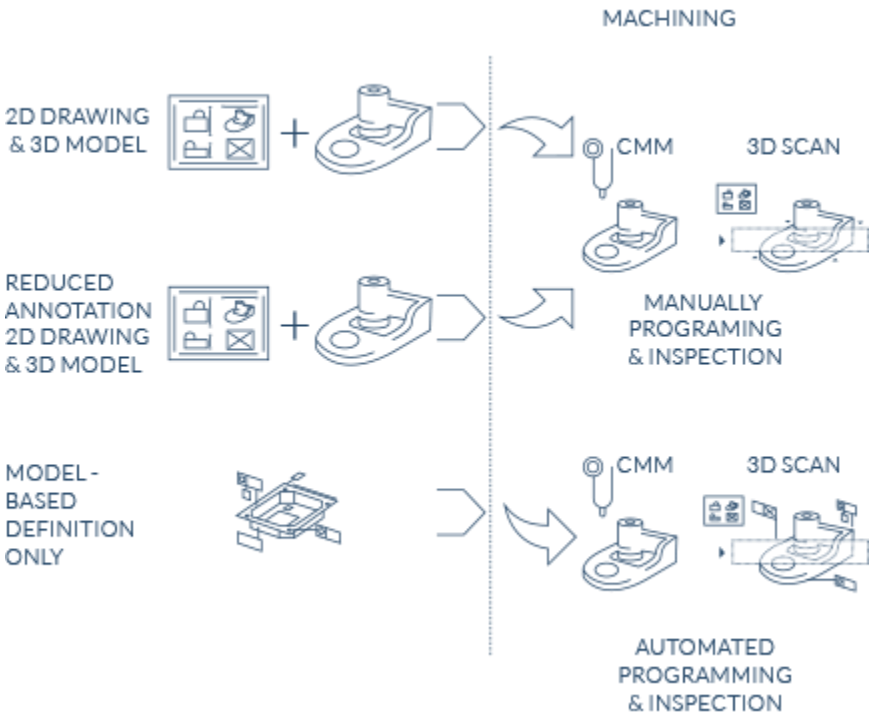


Figure 5: Stages in Quality's Transition During an MBE Initiative

The move towards reduced annotated 2D Drawings simplifies inspection for quality assurance. The deliverable only includes the means to *define the measurements and thresholds within which a component meets quality standards*. Inspectors must make few adjustments beyond requiring the ability to open and view such deliverables.

From a preparation perspective, the shift to creating and releasing an MBD requires few changes, regardless of an organization's practices and technologies, beyond training needed to open and view these new deliverables. However, quality organizations can realize improvements

with machine-readable PMI. Progressive inspection applications offer the ability to compare the ideal measurement from the MBD to the actual measurement from the physical part to see if the difference falls within the acceptable tolerance per the PMI in the MBD. This closes the loop on quality, opening the potential for automation. This applies to both CMM machines and 3D scanning approaches.

Overall, the transition for machinists involves three distinct steps.

- Inspectors need training to open and view either a reduced annotation 2D Drawings or an MBD. Training easily supported these manual approaches.
- The shift to an MBD with machine-readable PMI opens the opportunity for automation in inspection. To leverage this approach, departments must acquire a progressive inspection application that compare CMM measurements or a 3D scan to the machine-readable PMI in an MBD.
- Inspectors will also need training to create CMM inspection toolpaths, if this approach is used, as well as comparison of physical results to tolerances and other annotations.

MANAGING CULTURAL CHANGE

The adoption of Model-Based Enterprise initiatives requires more than new software. It requires cultural change, process modification, and training to help users upgrade their skills. This section provides guidance on how to navigate the cultural changes required for MBE success.

This section offers guidance on how to manage the cultural change that comes with adopting MBE initiatives.

LONG-TERM VISION, SHORT-TERM STAGES

Executive leaders must paint a long-term vision of how the organization will run after deployment of MBE efforts. Traditionally, organizations approach such an initiative without sufficiently preparing their user base. Some send invitations to attend training on the new software but fail to explain how the change would advance the organization's long-term vision and specific goals.

If users don't understand the big-picture benefits or why the changes are occurring, they have no vested interest in doing the heavy lifting that accompanies transformation. In addition, most of the change management work is on top of their regular responsibilities. Without a clear picture of how MBE advances the company's position, it's not certain that users will sacrifice and do double duty while they come up to speed.

To get the user base over this hump, the MBE implementation team and stakeholder group must share their vision at a public meeting. Once they clearly articulate the plan—for example, "We are embracing MBE to shorten development cycles and to release this

innovation to market before competitors"—management must reinforce the mandate through continuous communications to the enterprise, both electronically and live. It also helps to showcase critical milestones and ROI proof points in the context of the larger MBE mission.

Making an MBE initiative successful isn't just about developing and communicating a long-term vision. It also involves breaking up the effort into smaller, achievable projects. Most technology-led initiatives are just too broad to deploy and adopt in one fell swoop.

Defining and clearly articulating a long-term vision for an MBE initiative is key. It drives alignment and expectations for everyone involved.

A more common approach is to break up large-scale projects into stages—each providing some specific business value and set of capabilities—and to adopt those incrementally. This model lets users get comfortable with process changes and new ways of working, gradually. In addition, the approach fosters buy-in because the user community is privy to a steady progression of benefits. This builds trust in MBE's promise and reinforces the idea that change management routines are worth the time and effort.

As with the long-term vision, a solid communications plan is central to apprising users of milestones and requirements as part of the multi-stage roadmap. For instance, to get your team excited about and engaged with the MBE initiative, try the following: Send regular emails showcasing specific deliverables. Offer tutorials on different workflows and software functionality. Create case studies and peer commentary that call out specific benefits. Also, communicate short-term benefits and milestones in the context of the longer-term strategy. This keeps users abreast of the larger plan. Finally, invite executive stakeholders into the conversation to cement the importance of the milestone projects to the greater agenda.

AVOID MANDATES, SHARE OWNERSHIP

The value proposition of many technology-led initiatives requires upfront efforts to realize benefits downstream.

Unfortunately, this means more work for one or two roles. If you ask a longtime employee to make such a difficult change without benefits, it can backfire. When planning an MBE adoption plan, figure out a way to deliver benefits to those longtime employees or hire new employees to take on the more difficult tasks, redefining the role. It makes more sense to find the longtime employees new responsibilities and find new people to fill the more difficult task.

It is likewise crucial to find a win for each functional department. Forcing organizational change frequently results in cultural pushback. The key to switching this 'push' style model of technology adoption into a 'pull' style where constituents seek out the change initiative is to prove out benefits on a small scale. The idea is to test the change with a smaller-sized organization. Then document the advantages and benefits. Communicate successes to the rest of the company as part of a frequent outreach program. Next, approach adjacent departments and offer to help them realize the same value. Note, however, that once successes are broadcast in the company, department leaders start to approach the deployment team for their organization to be next in line for the initiative. This results in a slow but steady spread of the initiative.

Few MBD initiatives are successfully driven exclusively from the top down. Initiative leaders must engage many stakeholders and incorporate their input as part of the initiative to share ownership.

PREPARING FOR TOUGH DECISIONS: INITIATIVE VS. PRODUCTIVITY

Many agree to a process change when things are running smoothly, but what happens when the changes seem too onerous or lead to steps detrimental to productivity?

One way or another, conflicts arise at some stage of the MBE roll out. Whether it's mediating the outcome of proposed process changes, figuring out what to do when a project runs late, or settling on how to manage governance, all constituencies involved in an MBE deployment need a forum through which they negotiate

different viewpoints. This prepares executive leadership for tough choices when that day arrives.

As part of this preparation, it is important to talk through hypothetical scenarios where conflict arises and to define how to resolve the issue. One of the best ways to facilitate discussion is through cross-functional committees or the PLM project steering team. Stakeholders who representing all constituencies provide input on the process, using the parameters of the forum to ensure discourse stays positive and to keep things moving forward. Once they agree upon routes to resolution for the different scenarios, the cross-functional committees can keep everyone updated on potential outcomes so there is transparency every step of the way.

Training is a crucial component to any successful MBE initiative. Training methods, however, have made significant advances in recent years. Explore emerging approaches to training.

The adoption of an MBE initiative is progressive. The long-term vision must be broken into smaller, achievable phases. Once success is gained in one phase, it must be documented and shared with the rest of the organization.

INVEST IN PROGRESSIVE TRAINING

One important aspect of an MBE initiative is employee work practices. Successful organizational leaders must keep two things in mind: efficiency and effectiveness.

- Employees must be efficient in how they execute tasks. Many have so many responsibilities they cannot spend much time on any one of them. They must be able to complete tasks and move on.
- It's not just about getting the task done. Employees must execute tasks effectively and well. Poor execution not only turns into needless repetition but inconveniences those relying on that work.

Ultimately, work practices affect how effective and efficient workers are in a role. The quality of these practices directly impacts the productivity of the entire organization. Of course, practices vary dramatically; some are good, and some are bad. Organizations invest to improve those practices.

Many perceive training as involving a classroom setting, an instructor and a thick binder of exercises. Over the course of a week, the trainer leads the class through

those exercises in order, alternating between communicating new concepts and then putting them into practice with the exercises. Modern training programs have become far more progressive. They include the use of l short, online training segments, the integration of guidance in the context of software applications, and even the customization of training to use a specific company's product data. These new delivery mechanisms allow employees to access the right training at the right time through the right medium.

Organizations must operate in a lean manner for the foreseeable future. Employee effectiveness and efficiency factors prominently in the success or failure of those organizations. Training programs are proven tools to improve the work practices of those employees.

SUMMARY AND RECOMMENDATIONS

Adopting an MBE initiative involves far more than just installing software. Specific circumstances must be considered for different functional departments. Additionally, the cultural change side of the initiative must be explicitly planned and managed.

SUMMARY

- Engineering must be the first functional organization to changes in an MBE initiative. This starts with a shift to a Reduced Annotation effort and arrives at the creation and release of an MBD. During the company's transition, engineering must release both a 2D Drawing for functional departments that have not made the change and an MBD to those that have. Companies would be wise to leverage documentation automation capabilities of CAD software to eliminate extra work for engineering.
- Once engineering makes the change in an MBE initiative, any number of other functional departments start their changes. This includes procurement, tooling design, machining, and quality.
- Procurement departments do not face many technical changes to start using an MBD in TDPs. However, transitioning suppliers to this new way of work is daunting. Conducting survey-based studies to gain insight into suppliers' current operating state, current capability state, and future plans is invaluable in making the transition.

- Tooling design and machining are both mature in their use of 3D models. Their transition focuses on the shift from a 2D Drawing to an MBD for manually reviewing tolerances and other quality constraints. In machining, a greater opportunity exists in leveraging machine-readable PMI to automate the application of machining strategies, sets of toolpaths with the right speeds, feeds, and selected tools.
- In quality departments, the shift depends on the practices and technologies used. They use an MBD for manual inspection, programming, and checking CMM machine operation, as well as comparing them to 3D scans.
- In all departmental adoptions, training on new capabilities is crucial to success.
- Company leadership must define a long-term vision for the MBE initiative. However, they must split that initiative into short-term adoption projects to make the change feasible. Communicating this vision to those experiencing the change, and progress towards realizing it, is critical.
- Similarly, mandates from executive leadership often leads to failure. It is important to incorporate deep participation from those experiencing the change into the ownership of the initiative.
- Company leadership must plan for tough decisions regarding an MBE initiative. There will be times when they must choose between productivity, in terms of meeting a deadline, or adhering to the MBE effort. It is best to define the thresholds of sticking with the change and communicating it clearly.
- An MBE initiative will require training in engineering, procurement, tooling design, machining, and quality departments. But more importantly, it will require progressive training as

each advance through the MBE effort. Find and invest in such training resources.

RECOMMENDATIONS

- Start with a Reduced Annotation effort in engineering. Successfully deploy this change in design documentation to the rest of the functional departments before further pursuing a full MBD implementation. Success is achieved when everyone in the company recognizes that dimensions act to *define the measurements and thresholds within which a component meets quality standards* and not the definition to *convey the complete and detailed geometric form of a component*. It is also important to leverage documentation automation to avoid the redundancy of creating a 2D Drawing and an MBD.
- Next, engineering continues their transition to creating and releasing an MBD instead of a 2D Drawing. Simultaneously start the shift for quality department to manually use an MBD for quality planning and programming. Achieve and document success with measured improvement. Share that success with the rest of the company.
- The next progression is for quality to start using an MBD to automate the programming of CMM machines and in conjunction with 3D scans. Alongside that change, allow tooling design to start manually using an MBD instead of 2D Drawings to identify tolerances and annotations to affect tooling design documentation.
- Up next, tooling design moves to embed PMI in their own models, or transfer PMI from the design to the tooling geometry. Simultaneously, machining starts using an MBD from engineering and tooling design to replace the manual review of 2D Drawings. This consolidates the change for

machining, receiving an MBD from engineering and tooling, at the same time.

- The last internal transition is for machining to use an MBD to automate the application of machining strategies with feature-based machining. During this time, procurement conducts a survey-based study to identify suppliers' current operating state, current capability state, and future plans is invaluable in making the transition.
- Procurement, and the transition of the supply chain, comes next. With insight into supplier's readiness for MBE initiatives and lessons learned from navigating the MBE initiative internally, procurement agents assist suppliers on their own journey.

Chad Jackson is the chief analyst and researcher at Lifecycle Insights, providing insights on a range of technology-led initiatives across mechanical, electrical, embedded software, system, and IoT engineering.

CONTACT | EMAIL contact@lifecycleinsights.com | SITE www.lifecycleinsights.com