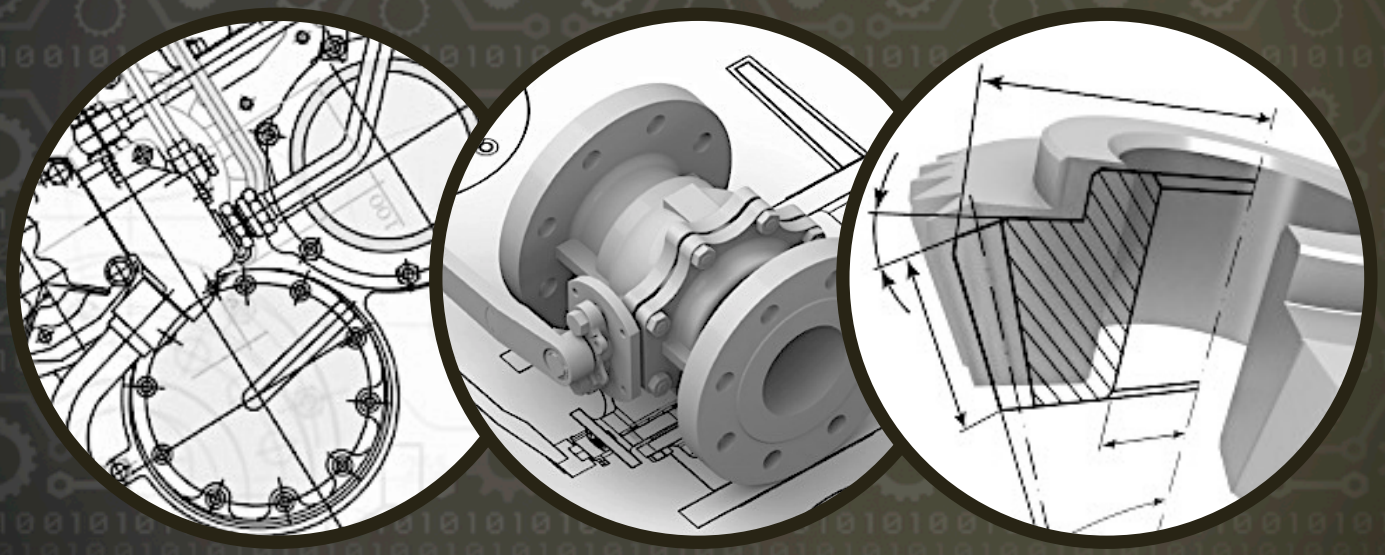
Quantifying the Value of Model Based Definitions:

Saving Time, Avoiding Disruptions, Eliminating Scrap



Benchmarking performance of those with varying adoptions of 3D Annotated Models as engineering documentation. Findings generated from the 2014 Model Based Enterprise Study.

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The Commitment Is Low. The Value Is High.

When it comes to the adoption of Model Based initiatives, the industry seems non-committal.

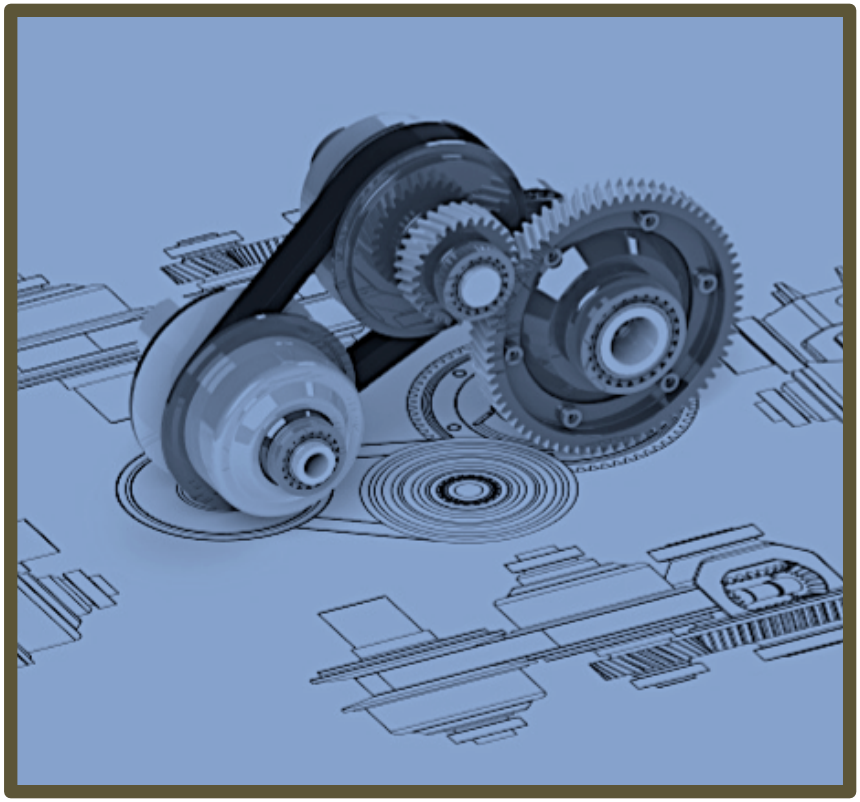
Fifty eight percent of the respondents to the 2014 State of Model Based Enterprise study have release 3D Annotated Models for engineering documentation for at least some of their designs. That means there are a lot of companies that are experimenting, either fulfilling contractual requirements or testing its value. However, few have fully committed to leveraging 3D Annotated Models as the main source of engineering documentation. Only 9% release 3D Annotated Models more than 2D Drawings. Furthermore, only 2% have gone completely with 3D Annotated Models as their only form of engineering documentation.

Despite the high rate of experimentation and the low rate of commitment, findings from the 2014 study show that there is value in Model Based efforts, a *lot* of value. After splitting the study's respondents into four groups ranging from strongly 2D Drawing reliant to 3D Annotated Model reliant, comparisons were made across several key metrics. The results clearly show that organizations that are currently heavily leveraging 3D Annotated Models are reaping certain advantages, including:

- Spending 6.6 fewer hours per week on engineering documentation
- Addressing 2.5 fewer emergency issues (change orders, reprioritized resources, etc.) per month
- Assessing why parts don't fit together 4.9 fewer times per month

How were the groups defined? What questions led to these metrics? How do these advantages translate into performance? How would the use of 3D Annotated Models provide such advantages? Therein lies the purpose of this eBook. Here, you'll find more information on the research methodology as well as insight into the three advantage areas.

This study shows that we're still in the early stages of adopting Model Based Definitions. But this study also shows that the effort is worth it.



Research Methodology and Cohort Definitions

Before diving into the performance findings that show a difference between leveraging 2D Drawings and 3D Annotated Models, it is important to explain exactly how the research cohorts were defined.

Lifecycle and Basis of the Study

First, here is the background on the State of Model Based Enterprise study. In May and June 2014, Lifecycle Insights surveyed 575 respondents to understand their practices and adoption of technology with respect to engineering documentation.

The findings of this study, however, are based on a subset of these respondents, totaling 366, who directly participate in the product development supply chain. Engineering service providers, software providers, service providers, and system integrators were excluded.

The survey for this study collected responses between May and June 2014 on SurveyMonkey. Survey respondents originated from three research partners, including Lifecycle Insights, Cadalyst and Design World as well as two software providers, including Geometric Limited and Siemens PLM.

Survey respondents were compensated for their time with a complimentary copy of the Engineering Manager's Survival Guide, an eBook published by Lifecycle Insights in July 2012.

Questions Used to Define Respondent Cohorts

For the purposes of this eBook, respondents to the study were grouped into cohorts characterized by their reliance on 2D Drawings or 3D Annotated Models for engineering documentation. The basis for this grouping depended on answers to two main questions.

- ***What percent of your designs have been released with PMI-embedded 3D Models?*** Answer options included: none (0%), little (1%-25%), some (26%-50%), majority (51%-75%), most (76%-99%) and all (100%).
- ***What percent of your designs have been released with 2D Drawings?*** Answer options also included: none (0%), little (1%-25%), some (26%-50%), majority (51%-75%), most (76%-99%) and all (100%).

Grouping Respondents into Like Cohorts

Two indexes derived from these two questions were then used to group respondents into like cohorts.

The first index calculated is the sum of the percentages for the release of 2D Drawings and 3D Annotated Models. Respondents whose summed answers were less than 100% were excluded from this analysis.

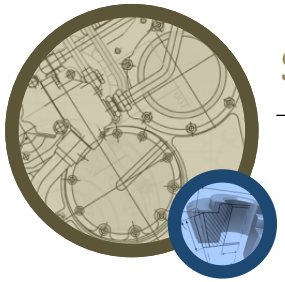
The second index calculated is the difference between the percentages for the release of 2D Drawings and 3D Annotated Models. This number represented how much more frequently one type of engineering documentation was released for product designs than another.

Quantifying the Value of Model Based Definitions

This second index was then used as the means by which respondents were grouped together into like cohorts. This included:

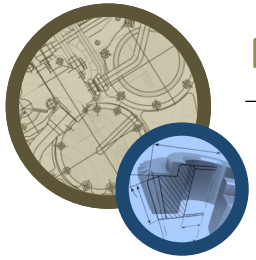
- ***Strongly 2D Drawing Reliant Organizations:*** These respondents release 2D Drawings for 76% to 100% more of their designs than 3D Annotated Models. This group represents respondents who are strongly or completely reliant on 2D Drawings as engineering documentation.
- ***Mostly 2D Drawing Reliant Organizations:*** These respondents release 2D Drawings for 26% to 75% more of their designs than 3D Annotated Models. This group represents respondents who are mostly reliant on 2D Drawings as engineering documentation.
- ***Balanced Organizations:*** These respondents release 2D Drawings for 25% or less of their designs than 3D Annotated Models. This group represents respondents who are fairly even in their release of engineering documentation between 2D Drawings and 3D Annotated Models.
- ***3D Annotated Model Reliant Organizations:*** These respondents release 3D Annotated Models for 26% or more of their designs than 2D Drawings. This group represents those who primarily or completely rely on 3D Annotated Models for engineering documentation.

The table on the following page depicts the breakdown of the respondents in greater detail.



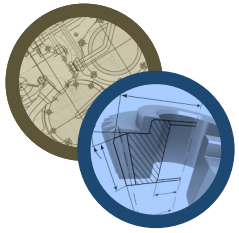
Strongly 2D Drawing Reliant

Release 2D Drawings for 76% to 100% more of their designs than 3D Annotated Models



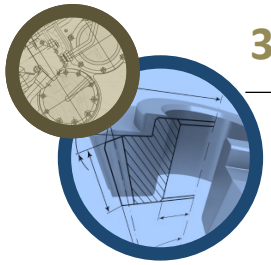
Mostly 2D Drawing Reliant

Release 2D Drawings for 26% to 75% more of their designs than 3D Annotated Models



Balanced Released Deliverables

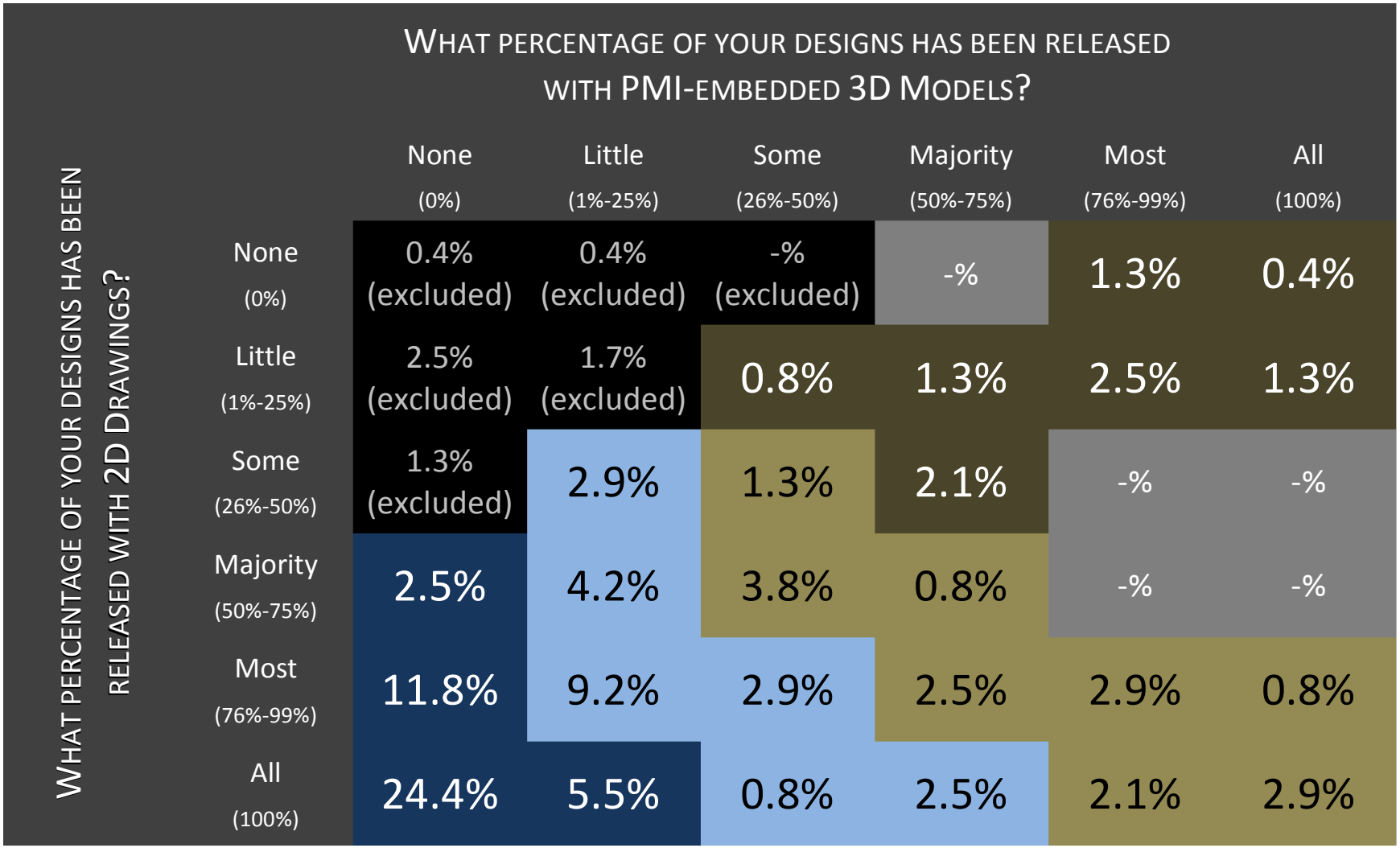
Release 2D Drawings for 25% or less of their designs than 3D Annotated Models



3D Annotated Model Reliant

Release 3D Annotated Models for 26% or more of their designs than 2D Drawings

Quantifying the Value of Model Based Definitions



Strongly 2D Drawing Reliant

Mostly 2D Drawing Reliant

Balance Release Deliverables

3D Annotated Model Reliant

Saving Time on Engineering Documentation

The first set of metrics to compare across these four cohorts of respondents is the total amount of time spent on engineering documentation, on average, per week. The statistics for these findings come from three separate open field questions in the survey where numerical answers could be entered, including:

- How many hours per week does an average engineer in your company spend creating documentation (2D or 3D)?
- How many hours per week does an average engineer in your company spend answering / clarifying questions for downstream users, including creating special 3D or 2D snapshots or views?
- How many hours per week does an average engineer in your company spend generating additional documentation for clarification?

Taking the average value within each cohort group provides findings as shown in the chart on this page.

Findings: Comparative Time Savings

Overall, the total number of hours that an engineer spends on engineering documentation steadily decreases going from the cohort most dependent on 2D Drawings to the one most dependent on 3D Annotated Models. More specifically, the **3D Annotated Model Reliant** cohort spends 6.6 hours less on engineering documentation than the **Strongly 2D Drawing Reliant** cohort, representing a comparative drop of 24%.

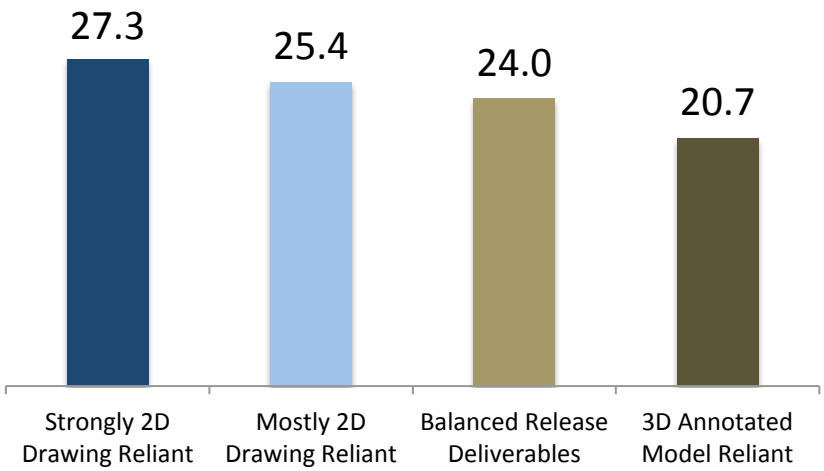


Figure 1: Average total hours an engineer spends creating, clarifying or amending engineering documentation.

Organizational Impact: More Time for Design

The impact of the difference in the amount of time each cohort spends on engineering documentation should not be underrated. Translated into a full year of work, such time savings translates into more than 40 full eight-hour workdays.

Additionally, the generation, clarification and extension of engineering documentation is not a strong value add to the product development process. Engineering documentation is the definition by which components, assemblies, systems and entire products are manufactured against. However, such engineering documentation does not have a value-add role in the design and development process. As such, minimizing the amount of time spent on engineering documentation is beneficial, as that time can instead be spent on design.

Advantage Explained: How Is Time Saved?

One of the clearest explanations of how time is saved by the **3D Annotated Model Reliant** cohort in comparison to the **Strongly 2D Reliant** cohort comes from one of the respondents of the study.

> *"Many people have trouble visualizing an object from 2D views, even with standard orthographic projections. I have no problem 'seeing' a part, but I have over 40 years of experience in PCB design and mechanical layout. 3D models and drawings do, however, help others understand exactly what they are seeing."*
>
> *Anonymous, Machinery Manufacturer, United Kingdom*

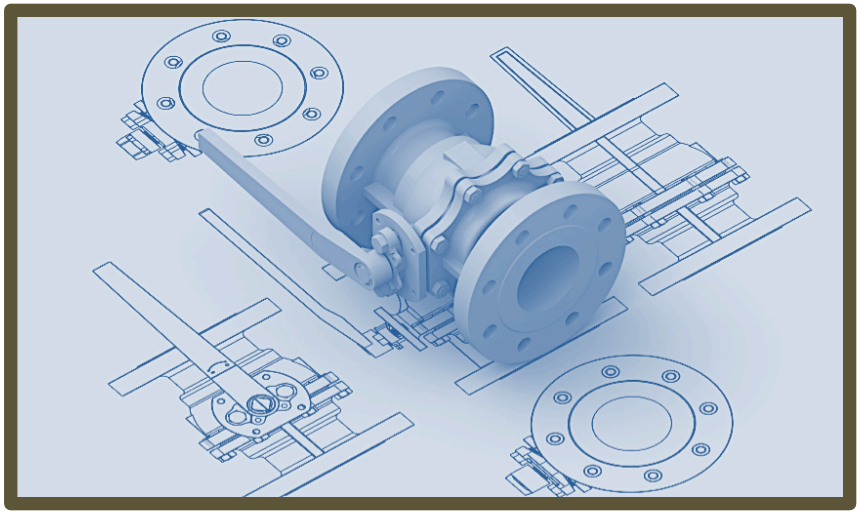
2D Drawings of components require interpretation. Lines that are "dashed" are hidden, or exist behind the solid of the component. In more complex cases, there can be many such hidden lines that overlap. Three orthogonal views of the component provide enough information to definitively determine the entire dimensional and spatial shape of the component. Isometric views offer an additional perspective of the component that helps clarify the component.

Engineers have used this standard definition to create 2D Drawings for nearly a century now. It has become the means to communicate their production intent to manufacturing, procurement and more. The challenge, however, is that interpreting such deliverables requires specialized training, even for non-engineers. Furthermore, it can be difficult for those without a high visual-spatial intelligence. Ultimately, this leads to additional requests for clarification and forms of documentation.

In comparison, 3D-based forms of engineering documentation are closer to the experience of holding a component in your hand. It can be spun while rendered, offering a means to visually inspect the part. Furthermore, such models can be interrogated in 3D, providing a clearer means to verify measurements.

Despite the greater ease of visualizing the 3D model, some specialized training is required. Engineering uses specific types of Product and Manufacturing Information (PMI) including Geometric Dimensioning and Tolerancing (GD&T), surface finishes, material selections and definitions as well as much more that needs orientation for non-engineers.

Overall, the barrier to interpreting 3D Annotated Models is lower than that for interpreting 2D Drawings. The fact that 3D Annotated Model reliant cohorts spend less time on engineering documentation than their peers who are Strongly 2D Drawing reliant is based on that reality.



Avoiding Design Emergencies

The second set of metrics to compare across these four cohorts of respondents is the number of times that the engineering organization has to address a design related emergency issue. The statistics for this finding come from single open field questions in the survey where numerical answers could be entered.

- How many times per month are resources reprioritized to address emergency issues (change orders, recalls, stop shipments, etc.)?

Taking the average value within each cohort group provides findings as shown in the chart on this page.

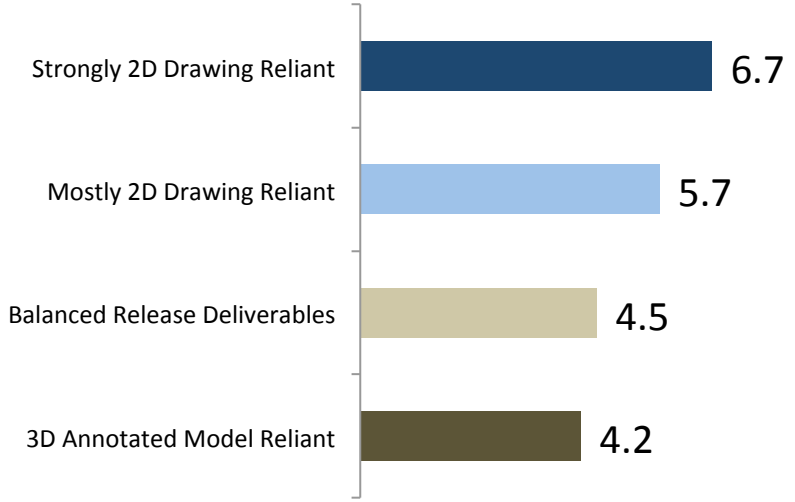


Figure 2: Average times per month resources are reprioritized to address emergency design issues.

Findings: Avoidance of Design Emergencies

The average number of times that the engineering organization must reprioritize their work decreases going from the cohort most dependent on 2D Drawings to the one most dependent on 3D Annotated Models. Specifically, the **3D Annotated Model Reliant** cohort reprioritizes their work 2.5 fewer times per month compared to the **Strongly 2D Drawing Reliant** cohort, representing a comparative drop of 37%.

Organizational Impact: Deadlines Don't Move

The disruption of ongoing design and engineering projects is a frequent but under recognized issue in product development today. Furthermore, the impact of such disruptions is not completely understood by organizational leaders. However, engineers definitively feel the pain of such disruptions.

The scenario is an all too familiar one. A critical problem arises downstream in manufacturing, procurement, quality or service. It might manifest as a production issue, a recall or failure at the customer's site. Regardless of the actual issue, the resulting process is very similar: the engineer must lead a process to determine the root cause, develop a solution and release it to the rest of the company.

While necessary, this process disrupts ongoing new development projects. The primary resulting issue has to do with time. Executive leaders have placed a premium on meeting deadlines for new development work because they understand the importance of time to market. As a result, the engineering organization must catch up by putting in extra time.

Advantage Explained: How Are Design Emergencies Avoided?

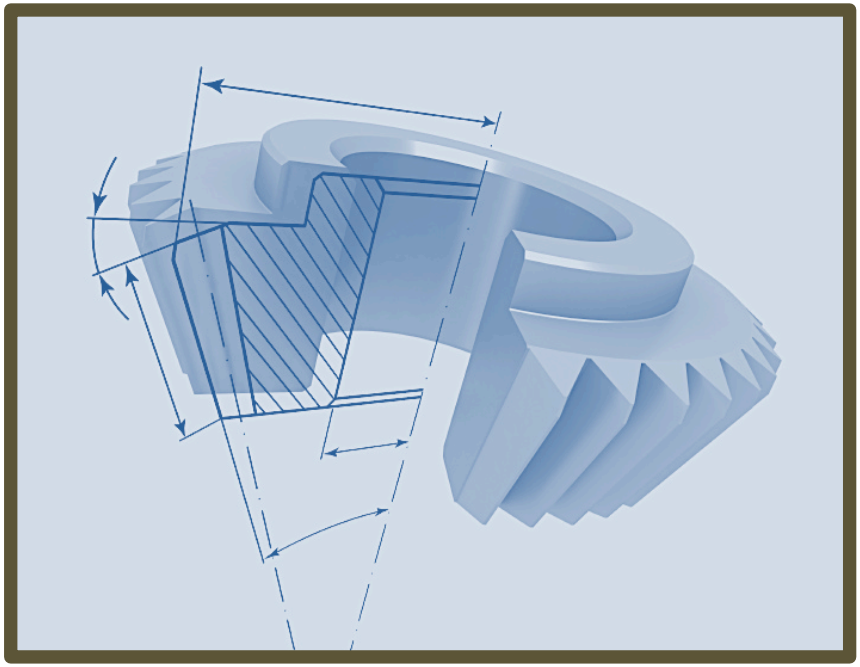
Early findings in this eBook showed that engineers could save time dedicated to engineering documentation because 3D Annotated Models are easier to interpret and require less additional clarification and documentation. Avoiding design emergencies, however, represents the other side of interpreting engineering documentation. Instead of requesting additional clarification or documentation, the downstream consumer misinterprets the engineering documentation, causing an error that proceeds further downstream in the product development process.

The possibility for such errors with 2D Drawings is relatively easy to understand. The fact that such deliverables require more specialized training and spatial-visual intelligence increases the chance of misinterpretation. In contrast, 3D Annotated Models as a deliverable have a lower barrier to consumption and interrogation. Overall, 2D Drawings simply pose a higher risk of misinterpretation than 3D Annotated Models.

One might question the need to trouble the engineering organization with such issues. The engineering documentation could be perfectly correct. A downstream misinterpretation should be addressed downstream. Considering the potential investments by the company, however, that thinking is flawed. Let's consider some examples.

Let's say that a machinist misinterprets a component's engineering documentation. The machinist produces a large number of the components with this error. Once the machinist recognizes the problem and makes the company aware of it, a choice must be made. If the components cannot function in the greater design, then they must be repurposed or turned into scrap. However, if the components can function in the design, then the engineer must tweak the design to accommodate the modified component. That's where the design emergency arises for the engineer.

To be clear, these findings show that this scenario is playing out for organizations regardless of their reliance on 2D Drawings or 3D Annotated Models. These findings are, however, showing that the organizations that rely on 3D Annotated Models more are encountering this problem 2.5 times less frequently than those that mainly rely on 2D Drawings.



Assessing Production Errors

The third set of metrics to compare across these four cohorts of respondents is the number of times that the company has to assess if engineering documentation caused production problems. The statistics for this finding come from single open field questions in the survey where numerical answers could be entered.

- How many times per month does your organization spend assessing why parts don't fit as a result of incorrect or misinterpreted engineering documentation?

Taking the average value within each cohort group provides findings as shown in the chart on this page.

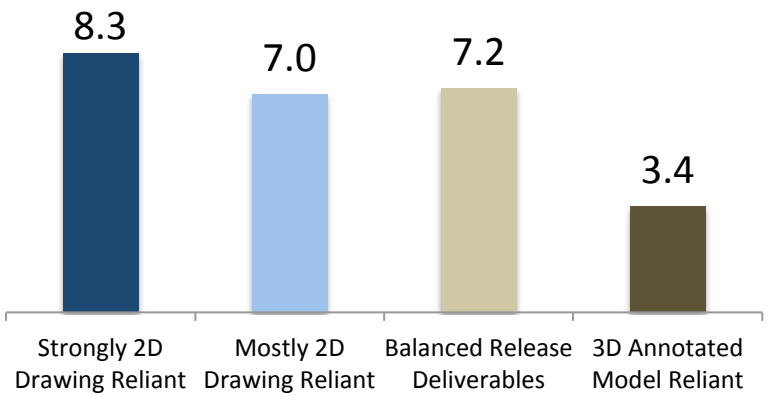


Figure 3: Average times per month the organization assesses why parts don't fit as a result of engineering documentation

Findings: Avoidance of Production Problems

The average number of times that the company has to assess why parts don't fit because of engineering documentation decreases going from the cohort most dependent on 2D Drawings to the one most dependent on 3D Annotated Models. Specifically, the **3D Annotated Model Reliant** cohort assesses production issues 4.9 fewer times per month compared to the **Strongly 2D Drawing Reliant** cohort, representing a comparative drop of 59%.

Organizational Impact: Avoiding Scrap and Waste

There will always be errors in the production process. That, however, doesn't mean that companies will always want to minimize them. The primary motivation lies in the fact that such errors often relate to monies lost in the form of scrap and waste. Certainly, some manufactured components that were made to an incorrect set of engineering documentation can be reused. However, many of them cannot be used to make products, so they are disposed of or recycled.

Advantage Explained: How Are Errors Avoided?

Ultimately, the lower rate of production errors relates back to the lower incidence of misinterpretations. It is more difficult for non-engineers to learn and retain the knowledge and skills required to interpret 2D Drawings compared to 3D Annotated Models. Whether it is because of misinterpreted engineering documentation or because of incorrect engineering documentation, the result is the same: more scrap and waste. Utilizing 3D Annotated Models more broadly lowers the rate at which this problem occurs because it is easier to interpret.

Summary and Conclusion

Today, findings from the 2014 State of Model Based Enterprise show that the adoption of 3D Annotated Models varies dramatically. Fifty-eight percent of the respondents release Model Based Definitions for some of their designs. Yet, only 9% rely on these deliverables as their primary source of engineering documentation. However, findings from this study show that those groups that rely more heavily on 3D Annotated Models are realizing a lot of value from those efforts, specifically in three distinct areas.

Saving Time on Engineering Documentation

Results show that the engineers in organizations relying more on Model Based Definitions than 2D Drawings are spending 6.6 fewer hours per week on engineering documentation. This is due to the fact that 3D-based documentation requires less training and retention in terms of being consumed by downstream participants, such as those in manufacturing and procurement. Engineers, in turn, can apply this time to design efforts instead.

Avoiding Design Emergencies

Findings from the study also show that these same organizations undergo 2.5 fewer reprioritizations due to design emergencies such as change orders or stop shipments. This means there are fewer disruptions for ongoing new product development efforts for the organization, increasing their chances to meet time to market objectives. It also translates into fewer hours in the office and lower rates of burnout for engineers performing this design work.

Assessing Production Errors

Such organizations also realize benefits in terms of the avoidance of production problems. On average, 3D Annotated Model reliant organizations assess production issues 4.9 fewer times per month than their counterparts. This is due to the fact that the use of 3D Annotated Models results in a lower misinterpretation rate than 2D Drawings. For the organization, this translates into a lower rate of scrap and waste on the manufacturing floor.

Closing

The value behind Model Based Definitions has long seemed logical. However, there has been little to no proof validating and quantifying that value. With the 2014 State of Model Based Enterprise study, we have some definitive answers to these outstanding questions.

For more information on Model Based Definitions, visit Siemens PLM site. Underwritten in part by Siemens PLM, all concepts and ideas developed independently as part of the 2014 State of Model Based Enterprise study, © 2013-2014 LC-Insights LLC.

Chad Jackson, the Principal Analyst of Lifecycle Insights, is a recognized authority on technologies that enable engineering, including CAD, simulation, PDM and PLM.

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