THE MODERN ENGINEER’S TOOLSET
POWERING THE NEXT GENERATION OF DESIGN

LIFECYCLE INSIGHTS
HOW ARE ENGINEERING ORGANIZATIONS PERFORMING TODAY?

Today, there is little doubt that designing products is intensely difficult. Engineers are presented with conflicting requirements and constraints, all of which must be solved with great designs developed on shorter schedules.

That difficulty, however, doesn’t negate the need to understand how successful engineering organizations are in achieving their goals. In fact, understanding how most engineering organizations perform in today’s strenuous operational environment offers a performance baseline. Comparing organizational performance between cohorts that employ different methodologies and technologies offer insight into what actually makes an impact.

To that end, as part of its The PLM Study, Lifecycle Insights surveyed engineering organizations about their organizational performance that would, in aggregate, measure the overall success of their product development projects. The results, shown in Figure 1, reveal shockingly low success rates. These organizations don’t meet product development goals for the vast majority of projects they undertake. One of five engineering projects are cancelled, translating into development costs that will never be recouped. Nearly another quarter of all projects miss their release dates, making it nigh impossible to launch or deliver the product on time. A little less than half of the remaining projects are released on time, but not without shifting resources around in an emergency mode. The reality is that only 15% of all projects are released on time without shifting resources.

Obviously, these are not desirable outcomes. But to better understand the root cause of these issues and glimpse some potential solutions, we must ask a simple question: why do so many engineering projects fail?

Figure 1: Disposition rates of product development projects, The PLM Study, January 2015, 760 respondents
THE TRENDS UNDERMINING ENGINEERING EFFECTIVENESS

To answer the question, we must consider the trends that are affecting engineering effectiveness. Overall, there are five predominant product development trends that conspire today to decrease engineers’ productivity and to derail development projects.

DESIGN IS INCREASINGLY DEMOCRATIC

Engineers are no longer the sole driver of a product’s form, fit and function. Today, they must ensure a wide array of stakeholders, inside and outside, which the company can review and provide feedback on product designs. As a result, engineers need technology that can quickly and easily share design information while protecting intellectual property. Furthermore, collaborating stakeholders need a way to suggest design changes to close the feedback loop. All parties with a role in the project need a way to exchange ideas and thoughts on the design. More details on this trend can be found at Lifecycle Insight’s site here.

TODAY’S PRODUCTS ARE INCREASINGLY COMPLEX

More than ever before, products now include dramatically more electronics and software. Customers are driving the transition of products into a product software and service ecosystem, a holistic combination of products and services. Customers are also demanding more customization, providing opportunities for differentiation between product offerings. In an effort to gain more market shares, manufacturers are looking to find ways to accommodate these requests for customized products. In virtually all aspects of product design, engineers are facing more complexity than ever before.

ENGINEERING WORK IS FUNDAMENTALLY VOLATILE

Design errors that get past design release can cause dire consequences for engineers. The change orders that return to their desks cause full-blown emergencies, wreaking havoc in the form of scrap, rework, and failed prototypes. Design errors take resources away from the ongoing development projects. In fact, 60% of the respondents from The Simulation Driven Design Study have missed project deadlines due to failed prototypes. Engineers can mitigate such volatility by adopting ‘get it right the first time’ principles that are supported by technology that validates product performance through early simulation and fast prototyping. This includes fast and easy geometry manipulation to prepare models for simulation and printing. More details on this trend can be found at Lifecycle Insight’s site here.
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THE TRENDS UNDERMINING ENGINEERING EFFECTIVENESS

SHORTER SCHEDULES, FIRST FEASIBLE DESIGNS

A consistent theme in product development is the shortening of schedules. Compressed schedules force engineers to accept the first feasible design they find. In the worst case, these designs marginally fulfill project objectives. As a result, the company is leaving ‘opportunities on the table’ to reduce product costs, create higher performing products or completely fulfill customer requirements. Engineers need technology that lets them fully explore all possible design alternatives to find the best option. The technology capabilities that fulfill these needs include manual approaches to more easily manipulate geometry. But it also includes more automated approaches to explore the design space.

NON-VALUE ADD ACTIVITIES STILL WIDESPREAD

Many different companies have adopted Lean approaches. They have even made their way into design and engineering organizations. A core Lean principle calls to eliminate non-value activities from processes. While many have attempted to deploy this in engineering, many tactical non value-added activities still exist throughout design. This includes the manual management of the design data and the recreation of the design data when existing sources cannot be found. They also include the import and cleanup of the design data exchanged in the supply chain. In fact, findings from The 3D Collaboration and Interoperability Study show that 49% of engineers spend at least 4 hours a week fixing broken geometry. Engineers need technological capabilities to automate these tasks so they can dedicate more time to design.

TAKEAWAYS ON TRENDS AFFECTING ENGINEERING

Many factors undermine engineering productivity and, thus, the effectiveness of engineering organizations.

Some of these factors are industry trends. That includes the integration of stakeholders who aren’t engineers into the design review process. It also includes the increasingly complex and customized designs that customers demand. And it includes shortened design cycles, which means that engineers don’t have the time to fully explore design possibilities and must spent their time dealing with design errors. Even a trend that would seem to help engineers, the adoption of Lean principles, hasn’t truly been embraced as intended by engineering organizations, meaning engineers still do extra work.

It’s of no surprise, when viewing these trends as a whole, that they make for less-than-effective engineering organization. Unfortunately, these issues directly impact their ability to release designs on time and without an emergency shift in resources.

Over the course of a 20-year career, Alex Paradiang, the engineering leader at Sunkist, has seen changes in pressures that are placed on engineers.

“Engineers sometimes have a difficult time seeing the bigger picture,” states Alex. “They really want to design something cool, but can sometimes lose sight of the user’s real need. That’s why we explicitly start to collect feedback from many people early on, especially when there is little investment in the design, so we can accommodate change.”
ENGINEERING’S TECHNOLOGY TOOLSET: THE OLD AND NEW

Technologies have long enabled engineers to effectively design products. Those technologies in aggregate, which can be considered a toolset, empowered them to develop great creations and achievements. In the light of the challenges that today’s trends present, however, yesterday’s toolset is no longer adequate. New technologies that have emerged can significantly enhance the effectiveness of today’s engineers. Here, we’ll consider the modern engineer’s need and, in that context, compare traditional technologies with emerging ones.

EXPLORING DESIGN ITERATIONS

Ultimately, engineers must find the design that works. But without the capability to explore design iterations, they risk taking the first feasible design rather than unearth a better one that might cost less, be produced quickly, and provide innovative features. The gap between traditional and modern technologies in this regard is significant.

- The traditional means to explore different design alternatives is to use Feature-Based Approaches to modify models. The problem, however, is that as more features are added to a model, more interrelationships are built. That, in turn, makes the model less flexible in terms of change and increasingly likely to fail. Engineers can end up spending a significant amount of time fighting with the CAD application instead of actually exploring design alternatives.

- A modern addition to exploring design alternatives is to leverage Direct Modeling Approaches to push, pull and drag geometry directly. This method, which does not use features, enables faster and easier geometry modification without the threat of time-wasting failures. The availability of both Feature-Based and Direct Modeling approaches allows engineers to use the right tool at the right time. In addition to this approach, Cloud-based Generative Design automates the exploration of the design space by building out many different alternatives within user-defined constraints. The result is numerous iterations that engineers might never have considered.

In all, modern technologies empower engineers to explore more design alternatives, which increases the likelihood that better designs will be found, and eliminates some of the non-value add activities from the design cycle.
ENGINEERING’S TECHNOLOGY TOOLSET: THE OLD AND NEW

SHARING AND COLLABORATING ON DESIGNS

Engineers don’t design in a vacuum. Design is increasingly democratic. Feedback from different technical roles and many stakeholders across the company must be incorporated to improve costs, performance and requirement satisfaction. This means engineers must have a means to share designs and foster interaction between stakeholders. This is another area where advances in the past few years have been significant.

- In The PLM Study, 90% of respondents used Email as a means to share design data between internal design engineers and suppliers. Unfortunately, this represents a significant risk to the protection of intellectual property, as models could be intercepted. But other detriments exist. This provides other stakeholders no means to actually view the design, forcing them to download, install and use unfamiliar technical applications. Additionally, emailed design data can be quickly outdated without notification, leaving other stakeholders to risk working on out-of-date data. Furthermore, emails can be easily lost or deleted. As a mechanism to provide feedback, email is a poor way to correspond as participants can be removed, forgotten and input isn’t in the context of the model. Overall, email is an inadequate means of sharing and collaborating on designs across the company.

- The pragmatic replacement, which has emerged within the last five years, is Cloud-Based CAD Data Management. This service allows engineers to manage their designs in cloud-hosted lightweight apps or through browsers. But more importantly, the designs that are managed in the cloud can be shared directly, providing a single source of truth that is never outdated. Once shared, stakeholders can view models via browser embedded visualization. Feedback is captured directly within the model, so it is always in context of the design and always alongside input from other participants. The entire process offers better methods to protect intellectual property as these offerings utilize more stringent security protocols.

Gathering and incorporating feedback from a wide range of roles is the new reality of engineering. Email is a dated and dangerous technology for this application. Cloud-Based CAD with Embedded Data Management offers a faster, easier-to-use and more secure means of executing these activities.

VIRTUALY TESTING PRODUCT PERFORMANCE

In this era of shortened design cycles, product designs must pass the first round of physical prototyping and testing. Testing digitally or virtually is an approach that allows engineers to verify and validate product performance before moving to physical prototyping and testing, where hard monies are invested. This is a technological area that has seen important advancements over the past decade, but continues to see progress in recent years.

- Today, engineers use a variety of methods to check product performance. One of the most common methods is to use hand calculations, either written out on graph paper or in spreadsheets. This approach is useful early on, but lacks fidelity for accurate results for detailed design and cannot be leveraged to explore many designs in an automated way. Another way of checking performance is
ENGINEERING’S TECHNOLOGY TOOLSET: THE OLD AND NEW

to engage expert analysts, either inside the company or with external consultants. While this provides highly accurate results, getting a timely response is challenging as these personnel often have deep queues of verification and validation work. This makes this approach a poor fit for fast moving design where answers are needed in hours, not weeks. Lastly, many engineers rely on longstanding experience. While there is no replacement for the experience, there is often not enough availability of tenured engineers to actively participate in all projects.

- **CAD Embedded Simulation** allows engineers to set up and run analyses independently. The advantage here is the ability to set up and execute simulations that provide direction for common design decisions and alternatives. Furthermore, simulation methods using distributed computing resources, including those in the cloud, can dramatically increase the coverage of the design space that is explored thoroughly.

Virtually testing product performance for supporting design decisions and exploring design alternatives is a crucial methodology that lets the organization avoid prototyping and testing failures. Modern technologies are a significant improvement over traditional approaches.

Building Prototypes and Functional Parts

The ability to test a product virtually doesn’t mean engineers can’t also improve how they build and test physical prototypes and build functional parts. New technologies have emerged that offer key benefits over traditional methods.

- The traditional and formal build-and-break prototyping and testing process is fraught with potential risk. Given the rising complexity of today’s products, prototypes are costly, both from monetary and time perspective. But furthermore, testing to failure only reveals the initial failure mode, not secondary and tertiary failure modes. Furthermore, there are limitations to the traditional subtractive machining and tooling production approaches used to manufacture components. In some cases, these are inadequate to make innovative next generation components.

- In contrast, more organizations are moving towards incremental and faster prototyping and testing processes. The idea is to build smaller scale partial prototypes more frequently to check performance progressively. An important technology enabler in this regard is 3D printing, which allows engineers to print parts and even assemble them into subsystems at their desk within hours. This dramatically reduces the time and costs of taking testing from screen to physical world. They also make the prototyping and testing step the final one. Furthermore, new production technologies that combine additive and machining manufacturing technologies are now making it possible to produce previously infeasible components. This removes many traditional manufacturing constraints on part design.

Building out physical, functional prototypes will always be a crucial step in the design process. With modern technologies, however, this traditionally painful process can be transformed into a faster and easier one.
ENGINEERING’S TECHNOLOGY TOOLSET: THE OLD AND NEW

GETTING CLEAN MODELS FROM OTHER CAD TOOLS

Engineers work with geometry from a range of sources, including suppliers and customers, each of which may use a different CAD application. To work with those models, however, engineers must find a way to get a clean and accurate representation of the design into their own CAD application. While interoperability has been a longstanding traditional problem, important advancements have arrived.

- The traditional approach to working with models coming from other CAD applications has been to import or translate the geometry. Unfortunately, this results in broken geometry with gaps between entities, surfaces or curves that have been moved and even completely missing items. To get to a clean and accurate representation of the original design, engineers have to invest significant effort to fix those problems. Findings from The 3D Collaboration and Interoperability Study show that 49% of engineers spend at least 4 hours a week fixing broken geometry.

- Fortunately, new technologies have arrived that allow CAD applications to open models created in other tools in their native format, without translation. This functionality, powered by 3D visualization capabilities, provides a clean and accurate representation of the design, even thought it originated in a different CAD application. But furthermore, they offer a means to associatively update to modifications made in the original CAD application.

MODIFYING MODELS FROM OTHER CAD TOOLS

Getting a clean and accurate representation of a design is often merely a precursor to other engineering work. Sometimes, modifications are required for a design to incorporate it into a larger product. Other times, tweaks are needed to prepare the design for simulation or manufacturing. Regardless of the activity, engineers need a means to change models regardless of their originating CAD application. The problem, of course, is that models brought in from other CAD applications are stripped of the features used to build the geometry. Therefore, there are no features, the mechanism by which geometry can be modified, to make changes.

- When models come from other CAD applications, engineers have traditionally created new features to make changes. This is problematic as this approach is time intensive, complicated and duplicative of the original design effort. When models come from the same CAD application, engineers often try to manipulate existing features. The challenge in this scenario is the likelihood of model failure, especially in more complicated models, as the interrelationships between features are difficult to navigate. In both cases, engineers often recreate the model as this represents less of a time investment.
ENGINEERING’S TECHNOLOGY TOOLSET: THE OLD AND NEW

- The modern alternative is to utilize Direct Modeling to push, pull and drag geometry to make the necessary changes. This approach works on models coming from other CAD applications, where no features exist to modify, as well as models coming from the same CAD application, where existing features are too complex or inflexible for change.

It is a stark reality today that engineers must be able to modify designs that come from others, whether that be from the same or other CAD applications. Modern technologies, like Direct Modeling, make this task easier and faster than it has ever been.

TRACKING DESIGN CHANGES

Fundamentally, engineering is all about exploring and iterating to find feasible and better designs. This not only includes geometry changes, but also product performance and requirements fulfillment. This is yet another area where technology has made significant progress in recent years.

- Per The PLM Study, 44% of engineering organizations manage mechanical design data on desktops and laptops with another 59% managing it on shared drives. Companies utilizing either, or both of these methods take a significant risk with data loss, as files can be overwritten, lost or forgotten. But furthermore, all of these require manual effort, placing another non-value added task on engineers.

- In contrast, Cloud-Based CAD with Embedded Data Management offers more redundancy and automation. Such services track and save every modification made to the design, which can be archived, eliminating the chance that data could be lost. Furthermore, more intelligent search functionality makes it easier to find data compared to operating system based search tools that cannot understand the information inside models.

Tracking changes to design has traditionally been a manual and arduous task. Modern technologies, however, make this necessity more hands free and secure.

TAKEAWAYS ON TECHNOLOGY CAPABILITIES

Many of today’s commonly used technologies are sorely lacking in capabilities that help engineers do their jobs. They eliminate non value-added aspects of their jobs. They enable them to share and collaborate with others. They assist in building virtual and physical prototypes. In aggregate, this modern engineer’s toolset provides significant advances to help design projects stay on schedule.
THE CORRELATION OF TECHNOLOGY AND PERFORMANCE

Logically, advanced technologies should have a positive impact on organizational performance. But do they? Findings from The PLM Study offer some answers. Specifically, analysis of that study’s survey data revealed substantial differences in an engineering organization's ability to avoid recreating engineering data and to hit design release dates.

GROUPING RESPONDENTS BY LIKE TECHNOLOGIES

The PLM Study includes a range of performance and technology adoption questions as a means to measure industry adoption. In this analysis, answers to these questions were used to group the respondents into cohorts according to how progressively they had adopted technologies. Each respondent was awarded progressively increasing scores for more advanced technologies across six different application scenarios. Scores were summed across these scenarios to create an index. Then the respondents were grouped into the Top Quartile, Middle Half, and Bottom Quartile of respondents according to that index. The complete Cohort Segmentation Methodology is detailed on page 14.

Once grouped, each cohort’s performance was averaged and compared. The ability of these three cohorts to hit organizational performance measures were then compared and contrasted.

GENERALIZED TECHNOLOGY PROFILES

To understand the impact that technology can make on organizational performance, it is important to first look at the commonality of technology adoption within each cohort group. This is shown in Table 2.

<table>
<thead>
<tr>
<th>APPLICATION</th>
<th>TOP QUARTILE</th>
<th>MIDDLE HALF</th>
<th>BOTTOM QUARTILE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Managing data</td>
<td>Software systems (92%)</td>
<td>Software systems (60%), Desktops, laptops and shared drives (40%)</td>
<td>Desktops, laptops and shared drives (78%)</td>
</tr>
<tr>
<td>Executing processes and projects</td>
<td>Software systems (76%)</td>
<td>Software systems (55%), Email and documents (45%)</td>
<td>Physically routing printed forms (50%), Email and documents (50%)</td>
</tr>
<tr>
<td>Collaborating amongst engineers</td>
<td>Software systems (62%), chat and messaging (22%)</td>
<td>Email (40%), chat and messaging (35%)</td>
<td>Email (54%), chat and messaging (27%)</td>
</tr>
</tbody>
</table>

Table 2: Generalized Technology Profiles of Cohort Groups

The following generalizations apply to the following groups:

- **Top Quartile**: The majority use centralized software systems to manage design data, automate engineering processes and projects, and share and collaborate on designs.
- **Middle Half**: Characterized by mixed use of software systems with desktops, laptops, emails, documents and chat or messaging applications for engineering data, processes, projects and collaboration.
- **Bottom Quartile**: Primarily rely on desktops, laptops, printed forms and email to execute engineering development processes and manage design data.
THE MODERN ENGINEER’S TOOLSET

Sunkist Growers, the co-op of more than 6,000 members in California and Arizona, is best known for providing high quality fruits. However, hidden away, inside Sunkist lies a division that designs and develops industrial equipment. It all started back in the 1950s when the co-op wanted to automate their sort oranges by varying sizes, shapes, colors and grades. They built a research and engineering group that grew over time. Eventually, they realized that it was a profit-center with excellent competencies. That is the group that Alex Paradaing now leads. They have employed a number of technologies that enable and empower their design activities.

“Everything we create in engineering goes into our engineering data management system,” states Alex. “We start using it very early, even at the conceptual stage. While we’re pretty dedicated to it, I’m not forcing my engineers to use it. We realized if the system was cumbersome, they would simply use their C drive on their computers. So we use a system that works very similarly to how files are managed in an operating system. It has been great.”

“From a performance perspective, we do use simulation early in the design process”, continued Alex. “It gives us good insights. However, we also rely heavily on making prototypes with 3D printing. We utilize both early and throughout development right up until we are ready to make the mold. It allows us to make sure everything is right all the way through.”

THE CORRELATION OF TECHNOLOGY AND PERFORMANCE

LOWER RATES OF RECREATING ENGINEERING DATA

One area where the difference in organizational performance should be manifested is in the recreation of engineering data. Engineers utilizing a modern toolset should recreate design data less frequently. Findings from The PLM Study do, in fact, show that reality. Engineers within the top quartile of technology adopters recreate engineering data 10% less frequently on a weekly or more frequent basis. That means they’re more than 1/3 less likely to do so than their peers.

Figure 2: Engineering Data Recreation Rates

Engineers within top quartile organizations, which use software systems to manage their mechanical design data instead of desktops, laptops and shared drives, leverage search capabilities to reuse already-created data.

Sunkist Growers, the co-op of more than 6,000 members in California and Arizona, is best known for providing high quality fruits. However, hidden away, inside Sunkist lies a division that designs and develops industrial equipment. It all started back in the 1950s when the co-op wanted to automate their sort oranges by varying sizes, shapes, colors and grades. They built a research and engineering group that grew over time. Eventually, they realized that it was a profit-center with excellent competencies. That is the group that Alex Paradaing now leads. They have employed a number of technologies that enable and empower their design activities.

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THE CORRELATION OF TECHNOLOGY AND PERFORMANCE

HIGHER RATES OF HITTING DESIGN RELEASE

Lowering the rate of recreating engineering data is a clear benefit. Yet, executives often look for improvements that more closely affect the company’s balance sheet when considering technology investments. One such significant metric is the rate at which the engineering organization hits their release dates. Missing this deadline makes it more difficult to keep on schedule for a product launch or delivery, which in turn affects top line growth.

As was the case with recreating engineering data, findings from The PLM Study show difference in organizational performance in the cohorts of this analysis. Overall, top quartile organizations hit their design release dates 12% more frequently than the middle half without needing to shift more than 10% of the resources on the project. Comparatively, they are twice as likely to hit this key date than their peers. This counts as one additional project out of nine that is launched on time.

When it comes to releasing designs on time, numerous technologies are considered as contributing factors. The use of software systems to centrally manage revisions and provide access to mechanical design data eliminates the manual effort required to track design changes and recreation of engineering data. Executing projects and processes with software systems instead of email eliminates the loss of data and delays in processes. The use of software systems as the basis of sharing and collaboration means everyone is accessing and corresponding against a single source of truth. In aggregate, these technologies make a difference.

THE TAKEAWAYS ON PERFORMANCE DIFFERENCES

These software technologies obviously have a direct impact on the performance of engineering organizations. However, make note that no single technology is directly responsible for these differences in performance. Analyses comparing performance across individual technologies were conducted. Yet, they showed no differentiation. It was only when the combinations of these technologies were used to group respondents into cohorts that performance differentiation emerged. The takeaway? It is the combination of technologies, which can be considered a toolset, which makes a difference.

Figure 3: Frequency of Hitting Design Release Dates
RECAP AND CONCLUSION

Today, designing new products is not easy. Findings from The PLM Study prove that only 15% of all engineering projects go as planned, hitting their release dates without a 10%+ shift in resources. Why is it so difficult? Numerous trends have undermined the effectiveness and productivity of engineers.

TRENDS UNDERMINING ENGINEERING PRODUCTIVITY

Design is increasingly democratic, with stakeholders from all over the company needing to provide input. Products are increasingly complex as they include more and more electronics and software. Design work continues to be fundamentally volatile, where design errors come back to engineer’s desks as time-intensive change orders. Schedules are only getting shorter, forcing engineers to accept the first feasible design they develop. All of this is happening while there is still a significant amount of non-value added tasks for engineers. This, and more, is undermining engineering productivity.

ENGINEERING TOOLSET: THE OLD AND THE NEW

The traditional engineering toolset is inadequate for the challenges that engineers are faced with today. Fortunately, a new engineering toolset has and continues to emerge. Direct Modeling and Generative Cloud-Based Design help them unearth better products. Cloud-Based CAD with Embedded Data Management assists in sharing and collaborating with other stakeholders and tracking design iterations. CAD Embedded Simulation and 3D Printing help build virtual and physical prototypes. Natively opening foreign models and Direct Modeling help work with designs from the supply chain. Collectively, these technologies represent the new toolset for the modern engineer.

CORRELATING TECHNOLOGY AND PERFORMANCE

Findings from The PLM Study show that these technologies make a measurable impact on organizational performance. Top quartile organizations recreate engineering data less frequently, eliminating non-value added tasks. They also hit their release dates without a major shift in resources more than twice as frequently, adding up to one more project out of every nine that stays on schedule.

FINAL TAKEAWAYS

There’s no doubt -- engineering is facing new and formidable difficulties. The traditional engineering toolset is no longer enough. New technologies combined into a modern engineering toolset make a measurable impact on organizational performance. It is finally time to upgrade the toolset.

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Chad Jackson is an analyst, researcher and a blogger with Lifecycle Insights, providing insights on technologies that enable engineering, including CAD, CAE, PDM & PLM. chad.jackson@lifecycleinsights.com

More information on Lifecycle Insight’s studies can be found at the following links: The 3D Collaboration and Interoperability Study, The Simulation Driven Design Study and The PLM Study.
APPENDIX: STUDY BACKGROUND & ANALYSIS METHODOLOGY

This section provides information on The PLM Study as well as the methodology used for the analysis published within this eBook.

LIFECYCLE AND DEMOGRAPHICS OF THIS STUDY

The survey for the PLM Study was developed during December 2014. It was collected responses from 760 survey participants during the first two weeks of January 2015. The analysis included in this eBook was conducted in May 2015.

Respondents to the study’s survey serve a wide variety of industries, including: Industrial Equipment (29%), Aerospace and Defense (28%), Automotive (22%), Medical and Life Sciences (17%) and High Tech / Electronics (16%). Survey responses for this study were gathered from many geographic areas, including North America (69%), Asia (13%), Europe (12%) as well as Australia and New Zealand, South America, Africa and the Middle East (4%).

COHORT SEGMENTATION METHODOLOGY

The following describes the process used to group respondents into separate cohorts.

1. Respondents were progressively assigned with progressively higher values for the most advanced technologies in use. For example, those using desktops to manage their design data were given a score of 2. Those using centralized software systems were given a score of 4. The complete scoring is detailed in the Table 2.

2. Scores were summed across an application or process environments to create an index score representing how progressive they are in terms of technology adoption. For example, scores were added across engineering doc management, requirements management, MCAD management, design review, design release and internal design collaboration.

3. Respondents were classified into cohorts according to their index score, creating comparable groups: the top quartile (top 25% index scores), the middle half (middle 50% index scores) and the bottom quartile (lowest 25% of index scores).

The analysis comparing the averaged performance of engineering organizations on the page 9 of this eBook was conducting using this cohort segmentation.

### Table 2: Scoring Awarded in Cohort Analysis

<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>APPLICATION</th>
<th>TECHNOLOGY (SCORE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data Management</td>
<td>Engineering</td>
<td>Desktops or Laptops (1)</td>
</tr>
<tr>
<td></td>
<td>Documentation</td>
<td>Shared Network Drives (2)</td>
</tr>
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<td></td>
<td>MCAD Artifacts</td>
<td>Public Cloud-Based Services (3)</td>
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<td></td>
<td>Requirements</td>
<td>Software Systems (4)</td>
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<td>Process or Project Execution</td>
<td>Design Review</td>
<td>Docs and Email (1)</td>
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<td></td>
<td>Design Release</td>
<td>Desktop Apps (2)</td>
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<td></td>
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<td>Public Cloud-Based Services (3)</td>
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<td></td>
<td></td>
<td>Software Systems (4)</td>
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<tr>
<td>Collaboration amongst Internal Design and Engineering Teams</td>
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<td></td>
<td></td>
<td>Chat / Messaging (2)</td>
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<td></td>
<td></td>
<td>Public Cloud-Based Services (3)</td>
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