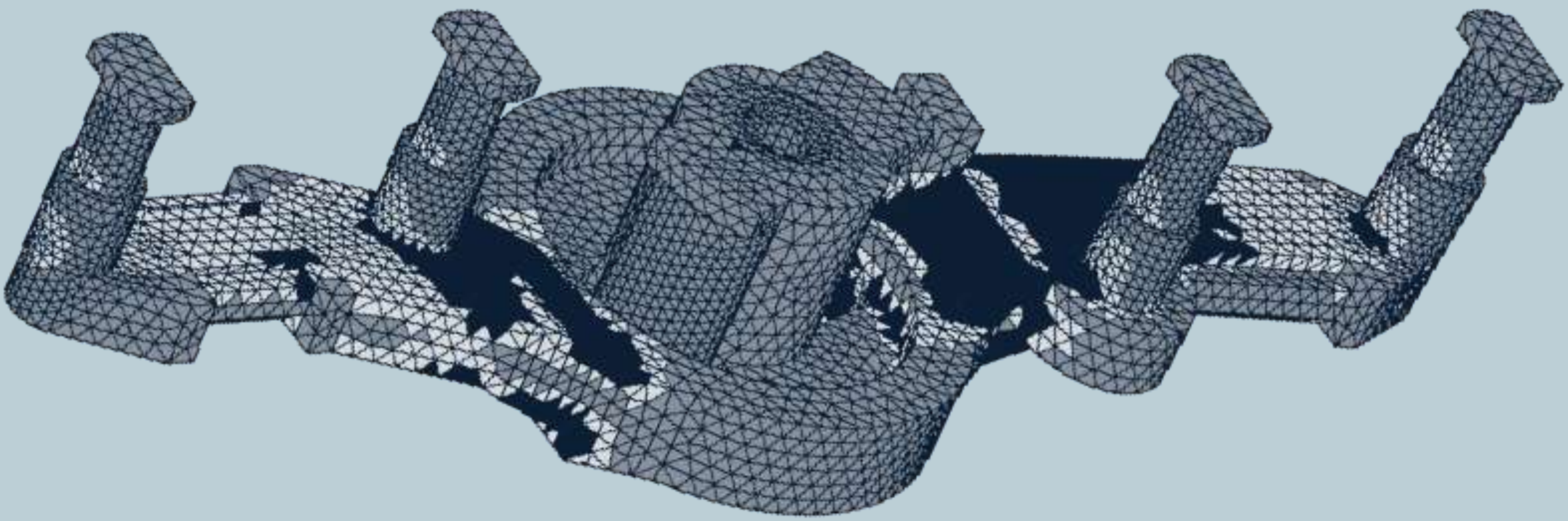
ENABLING SIMULATION DRIVEN DESIGN

ALIGNING PEOPLE, PROCESS AND TECHNOLOGY

LIFECYCLE INSIGHTS



HOW DO YOU BEST ENABLE SIMULATION DRIVEN DESIGN?

Managing product performance is a crucial aspect of any product development project.

Today, you'll be hard pressed to find anyone involved in engineering that disagrees with that statement. If you have prototypes fail in testing, it can have a devastating effect on the organization's ability to launch or deliver that product. If a product breaks down in the field or in a customer's hands, it can ruin a reputation or result in cancelled orders.

When it comes to managing product performance, engineering organizations have lots of choices, many of which aren't mutually exclusive. It is important to have good testing methods in place that close the loop on requirements. Groups of expert analysts now man the last steps of design release, running verification and validation processes digitally instead of physically. And while both of these competencies are vital to developing good products, neither has the ability to impact improving a design as much as a *Simulation Driven Design* strategy.

You see, a *Simulation Driven Design* strategy aims to conduct analyses during the conceptual and detailed design phases of development. The results provide greater insight to the engineers making the decisions for that design. Armed with more information about what variables affect performance, engineers can make better decisions. That can produce products that are lighter, faster, cheaper, and better differentiated.

The success of any strategy, of course, is reliant on the tactical execution of process and technologies, by the people involved. Ask the wrong role to perform those analyses, the organization likely won't reap the benefit. Have a prolonged and laborious simulation process, you likely won't get results in time to influence fast changing designs. Deploy difficult-to-use software tools, users will struggle with their tasks. So while many agree with the fundamental idea behind a *Simulation Driven Design* strategy, many still struggle with its tactical execution. Providing guidance on that topic is the purpose of this publication.

First, this eBook shares findings from a simulation research study linking the failure of prototypes to the inability to launch or deliver products on time. Next, it delves into the activities of expert analysts during Verification and Validation. After that, it details how design engineers might conduct their own analyses during design. Next, it looks at the characteristics of the enabling technology for the strategy. Finally, a recap of the entire eBook is provided.

Successfully developing products relies on an organization's ability to predict and manage performance. *Simulation Driven Design* strategies can be a key enabler of success. However, it needs the right people, process and technology to deliver.

PROTOTYPING FAILURES LINKED TO MISSED LAUNCH DATES

In January of 2015, Lifecycle Insights conducted research called The PLM Study that looked at product development performance as well as the IT environment used to support it. The findings uncovered as part of that study include:

- The industry saw 20% of all projects cancelled.
- Another 25% of all development projects outright missed their launch or delivery dates.
- An additional 42% of them required a 10%+ shift in resources to stay on schedule, which disrupted other ongoing projects.
- Only 13% of projects were launched or delivered on schedule without a disruptive shift in resources.

Most organizations find themselves in one of two states: 1) they consistently cancel projects or miss their launch/delivery dates, or 2) they are in a constant state of emergency as they shift resources between projects to stay on schedule.

Certainly compressed schedules and increasing design complexity are contributors to poor performance. However, delays in gaining insight into product performance also plays a role. Prototyping and testing are especially important in the product development, as many of today's products have functional requirements that must be fulfilled. A lack of understanding and foresight into product performance manifests as multiple rounds of prototyping and testing failures. As a result, significant delays and costs are introduced into product development.

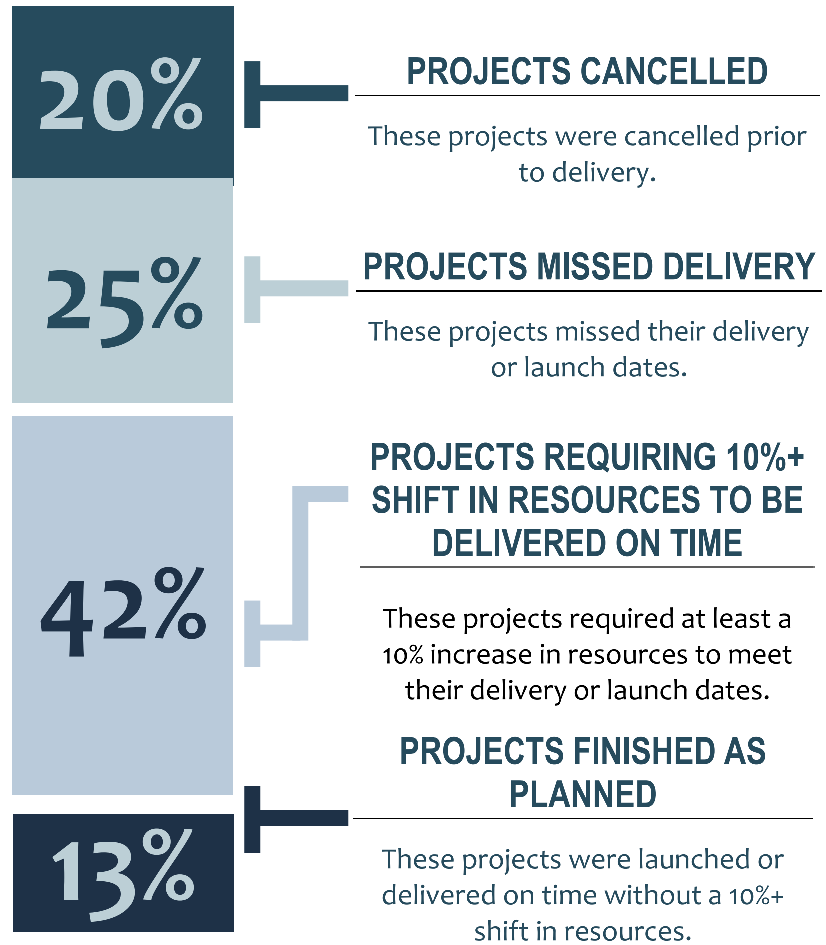


Figure 1: Disposition rates of product development projects, The PLM Study, January 2015, 760 total respondents

A tight correlation between prototyping and testing failures and poor product development performance was another hypothesis of The PLM Study. To test it, respondents to The PLM Study were asked how many projects, on average, hit scheduled design release dates. Respondents were also asked how many projects, on average, had three or more system-level prototypes fail. The conclusion, represented in Figure 2, is that there is a direct connection between the two. The darker areas of this heat map signify where a higher concentration of respondents lie. Specifically, more respondents lie in a band stretching from the bottom left to the top right. The trend is visually clear: as the number of projects with system prototype failures decrease, they are more likely to be released on time. The takeaway? Passing prototyping and testing the first time increases the chance that a project is released on time.

The outstanding question, of course, is how do you successfully prototype and test a product? Gaining insight into performance *during prototyping and testing* is too late in development, leaving little room to change the outcome. Ultimately, this is where simulation can provide tangible benefits. If used earlier and throughout the product development process, more insight can be gained while impactful changes can be incorporated. Simulation is a critical enabler to successfully passing prototyping and testing in fewer rounds. That, in turn, means fewer delays and costs in product development.

The outstanding issue, and the focus of the remainder of this eBook, is how best to enable simulation of a product's performance to avoid multiple rounds of prototyping and testing.

		Average number of projects, out of ten, hitting design release dates		
		1 or fewer	2 or 3	4 or more
Average number of projects, out of ten, with 3+ system level prototype failures	1 or less	10%	11%	26%
	2 or 3	13%	24%	27%
	4 or 5	16%	20%	18%
	6 or 7	19%	22%	16%
	8 or 9	42%	23%	12%

Figure 2: Heat map of prototype failures against design release, The PLM Study, January 2015, 760 total respondents

EXPERT ANALYSIS DURING VERIFICATION AND VALIDATION

There is little doubt that simulation and analysis has long been a critical technology for engineering organizations. Traditionally, the technology has been employed by expert simulation analysts during the verification and validation phase.

SPECIALIZED WORK BY A SMALL GROUP

Such expert users, who have often obtained a master's degree in engineering analysis methods, dedicate a large percentage of their day to day work on conducting simulations. Due to their specialization, there simply aren't a lot of them to hire in the market. As such, companies that do employ some of these simulation analysts frequently consolidate them into a specialized services group that support many different engineering groups and other departments.

From a process perspective, these small groups of experts usually work late in the design cycle, in the verification and validation phase, as a final check before engineering starts spending funds to build and test a prototype. The idea is to catch any issues that might cause a failure, which represents wasted monies and time.

VALUABLE WORK, BUT NOT ALL ENCOMPASSING

Employing simulation analysts during verification and validation is critically valuable. They allow the organization to avoid major issues that might derail a development project. However, while this strategy is beneficial, it doesn't address all of the prototyping and testing issues in design. There are numerous flaws, including:

- Waiting to perform simulations until this late in the development cycle leaves little room for changes because so many other components, assemblies and systems have been fully developed.
- Simulation analysts are small in number and have deep queues of work. This means they must focus on high value issues such as large key structural components and complex systems, leaving little time for common designs.
- Teams of analysts must also take on projects for products already in the field, such as uncovering the root cause of a failure for a product that has already been delivered. This also makes it challenging to dedicate any time to pre-release design work.
- Simulations conducted by expert analysts often focus on whether a design passes or fails its functional requirements as opposed to comparing many different design possibilities.

THE TAKEAWAY

Make no mistake: expert analysts conducting simulations during verification and validation deliver real and tangible value to the company. However, they are focusing on a different type of problem. More simulations performed earlier in the development cycle are needed to augment the work of expert analysts.

SIMULATIONS BY ENGINEERS IN DETAILED DESIGN

The primary means of augmented the work of expert analysts in verification and validation is called *Simulation Driven Design*. This strategy enables design engineers to conduct simulations during the design cycle. The advantage to this strategy is the ability to make better decisions because the engineer designing the component has greater insight into performance.

SIMPLER, DIRECTIONAL AND HIGHER VOLUME

While such a strategy might sound like it is simply moving the analysis activity earlier in the process, it actually has other key differences that must be considered, including:

- These simulations are **directional** in nature, as opposed to the *pass or fail* ones conducted during verification and validation. For example, an engineer can compare deflections of a design with three ribs instead of two.
- These analyses are often **simpler** than those performed in verification and validation. They often focus on components instead of assemblies, whereas those run by simulation experts focus on more complex physics or systems interactions.
- These analyses are run more **frequently** than those performed in verification and validation. They can be conducted for every single design decision, providing critical insight, if warranted.

KNOWLEDGE AND SKILL CONSIDERATIONS

The analyses that are run in *Simulation Driven Design* are simpler, more directional and more frequent. However, enabling engineers to conduct these simulations also needs some special consideration as well. Specifically, anyone running a simulation that is intended to influence a design decision needs skills and knowledge in four distinct areas:

1. **Background in Engineering Science:** To simulate performance to drive design decisions, you first have to know what the results of any calculation mean. This could include statics, dynamics, thermodynamics and many others that span other engineering disciplines.
2. **Understanding of the Computational Methods:** Next, to make sound decisions based on simulations, you need to understand the underlying method used to calculate resulting values. If you don't know the fundamentals of each of them, then you can't interpret results correctly.
3. **Familiarity with CAD Software:** In simulation driven design, results should drive changes in the design and ideally the CAD model. That model geometry is built using specific methods to capture design intent. As a result, the design should to be changed through the definitions created in the design model.
4. **Knowledge of Simulation Software:** Conducting simulations involves activities such as defining loads, constraints, complex material properties and the like. This requires software skills above and beyond CAD software knowledge.

While the list of skills and knowledge to adopt Simulation Driven Design looks long, it is achievable with the right combination of people, process and technology. In fact, it is likely that these skills and knowledge exist somewhere in most engineering organizations. Processes and procedures can be put in place to leverage those skills and knowledge as a team. And lastly, the right technology can enable those individuals to work collaboratively. In all, many engineering organizations can reap great benefits from a Simulation Driven Design strategy.

WORKLOAD CONSIDERATIONS

Any plan can seem sound in theory. When it comes to engineers, an important consideration to incorporate into any Simulation Driven Design strategy is time.

Lifecycle Insights' Hardware Design Engineer's study, conducted in August 2015, examined how engineer's spent their time. As part of that study, the survey included questions on the number of responsibilities each engineer carried. The study showed that engineers, on average, had 4.4 core design responsibilities, including things like developing engineering documentation, managing requirements, making design decisions and predict product performance. It also showed they had, on average, 2.9 extended design responsibilities, including things like project management, interacting with customers and managing suppliers. Needless to say, today's engineers are busy.

This is yet another consideration to take into account when planning any Simulation Driven Design strategy. It impacts how different roles interact. It also affects what kind of technology should be used to enable the process.

THE TAKEAWAY

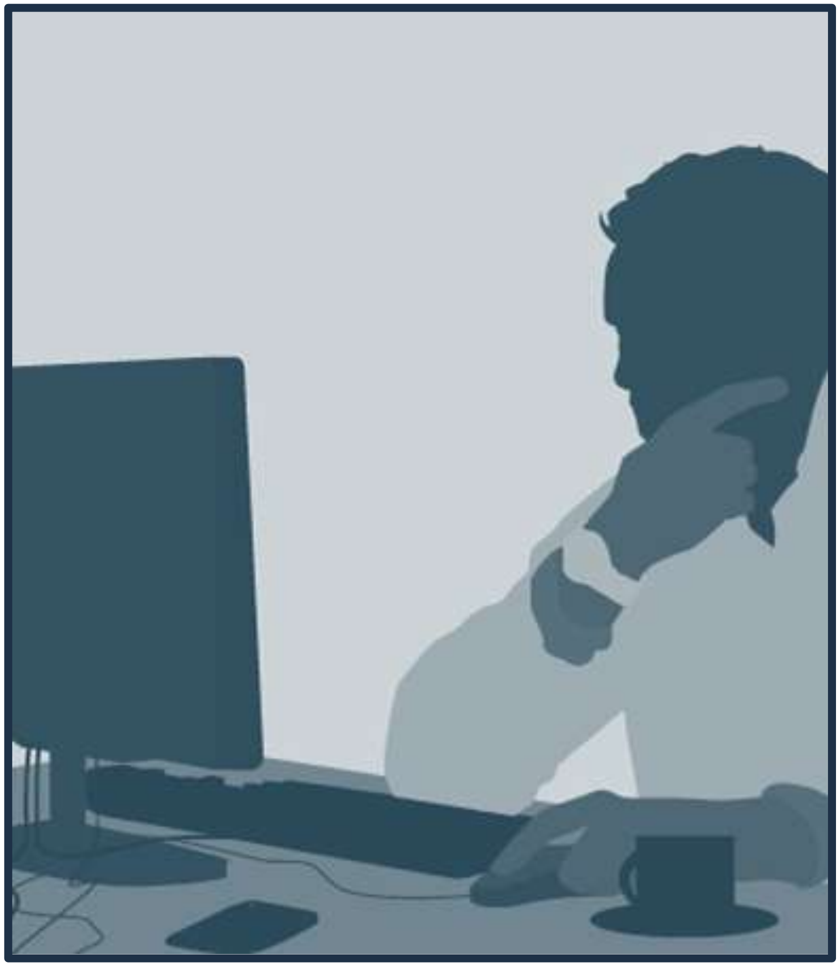
Adopting a Simulation Driven Design strategy, where engineers conduct their own analyses to make more informed and better decisions, is a natural fit to augment simulations conducted in verification and validation. When done with some proper planning in terms of people, process and technology, companies can reap great benefits.

PROFILING THE RIGHT SIMULATION SOLUTIONS FOR ENGINEERS

Simulation Driven Design strategies can have a dramatic positive impact for companies. But to successfully adopt such an effort requires some planning in terms of people, process and technologies. From a technology perspective, any simulation solution that can enable busy engineers must have the following capabilities.

- **Integration with CAD Applications:** Engineers will explore design alternatives in CAD applications. It must be easy to bring design geometry into the CAE application from a CAD application. Furthermore, it must be able to update the design geometry in the CAE application if it changes in the CAD application.
- **Easy to Learn:** Because engineers have little time to spare for simulations, they need to be able to pick up CAE solutions quickly and easily. This translates to simplified interfaces that don't overwhelm the user with all the capabilities of powerful CAE applications. It also translates to familiar interfaces with common UI paradigms that are easy to pick up.
- **Automated High Quality Meshing:** To avoid requiring engineers to be analysis experts, any simulation solution that will be used must have the ability to automatically create high quality meshes on behalf of the engineer that produce accurate results.

It is critical to employ the right technology in this case. As noted earlier, today's engineers carry many responsibilities and simulation requirements a wide set of skills and knowledge. Applying the right technology can make a big difference.



SUMMARY AND CONCLUSION

Managing product performance is a crucial aspect of any product development project. Simulation offers a means to gaining insight into product performance at many points in the development process. Simulation Driven Design strategies provides a means to gaining deeper insight into performance, enabling engineers to make better design decisions.

RESEARCH: THE KEYS TO STAYING ON SCHEDULE

Two findings from Lifecycle Insights' The PLM Study provides important insight into the link between failed prototypes and the ability to launch or deliver products on time.

- Only 13% of all development projects were launched or delivered on time. An astounding 43% required a 10%+ shift in resources to meet their schedules.
- Findings show a linear correlation between projects with 3 or more system prototype failures and their decreasing likelihood to release designs on time. Conversely, those with 1 or less projects with the same number of system prototype failures are much more likely to meet project timelines.

Overall, many companies are struggling to deliver products on time from the development process. Furthermore, companies that can ensure they minimize prototype failures are more likely to hit their delivery and launch dates.

SIMULATION DRIVEN DESIGN STRATEGY EXECUTION

Expert analysts provide tremendous value in the development process by verifying performance before prototypes are built for testing. However, these experts are typically few in number, focus on specialized and more complex simulations and do their work very late in the design cycle, when most variables have been locked down.

Engineers, on the other hand, can conduct simpler and more direction analyses in the detailed design phase, where that insight can be applied directly to making better decisions. Enabling such simulations by engineers means organizations must address challenges related to skills and knowledge as well as take their workload into consideration as well. The right technologies for simulation driven design by engineers needs integration with CAD applications, easy-to-learn characteristics and automated high quality meshing.

A Simulation Driven Design strategy offers considerable value. Organizations need to employ the right people, processes and technology to reap success.

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LIFECYCLE AND DEMOGRAPHICS OF THE PLM STUDY

THE PLM STUDY

The PLM Study researched the state of adoption of Product Lifecycle Management (PLM) solutions as well as its associated organizational performance benefits.

During the first two weeks of January 2015, Lifecycle Insights surveyed 760 respondents to organizational performance and use of PLM related technologies, including data management, project and process automation, sharing and collaboration and development reporting and oversight.

The number of respondents to the survey totals 760. The findings of this study, however, are based on a subset of these respondents, totaling 459 that directly participate in the product development supply chain. Responses from software providers, service providers and system integrators were excluded.

Respondents to the study's survey serve a wide variety of industries, including: 29% Industrial Equipment, 28% Aerospace and Defense, 22% Automotive, 17% Medical and Life Sciences and 16% High Tech / Electronics. However, these industries were not served exclusively. Fully 35% of the respondents designated that they serve more than single industry.

Survey responses for this study were gathered from the following geographic areas: 69% North America, 13% Asia, 12% Europe as well as 4% Australia and New Zealand, South America, Africa and the Middle East.

THE HARDWARE DESIGN ENGINEER'S STUDY

The Hardware Design Engineer's Study researched the correlation of engineer's traits and characteristics to compensation and technology use.

Between August 7th and 12th 2015, Lifecycle Insights surveyed 354 respondents to understand the correlation of the key traits and characteristics of engineers that most closely correlated to higher compensation and technology use.

The number of respondents to the survey totals 354. The findings of this study, however, are based on a subset of these respondents, totaling 251, that exclude software providers, service providers and system integrators.

Respondents to the study's survey serve a wide variety of industries. The industries served at the highest rates by the survey respondents include: 33% Industrial Equipment or Heavy Machinery, 31% Engineering Services, 28% Aerospace and Defense, 25% Automotive and 21% Consumer Products. However, these industries were not served exclusively. Fully 42% of the respondents designated that they serve more than single industry.

These respondents are employed at companies with a wide range of revenues, including: 57% from companies with less than $100 million in revenues, 23% from companies with revenues between $100 million and $1 billion in revenues and 20% from companies with revenues more than $1 billion.