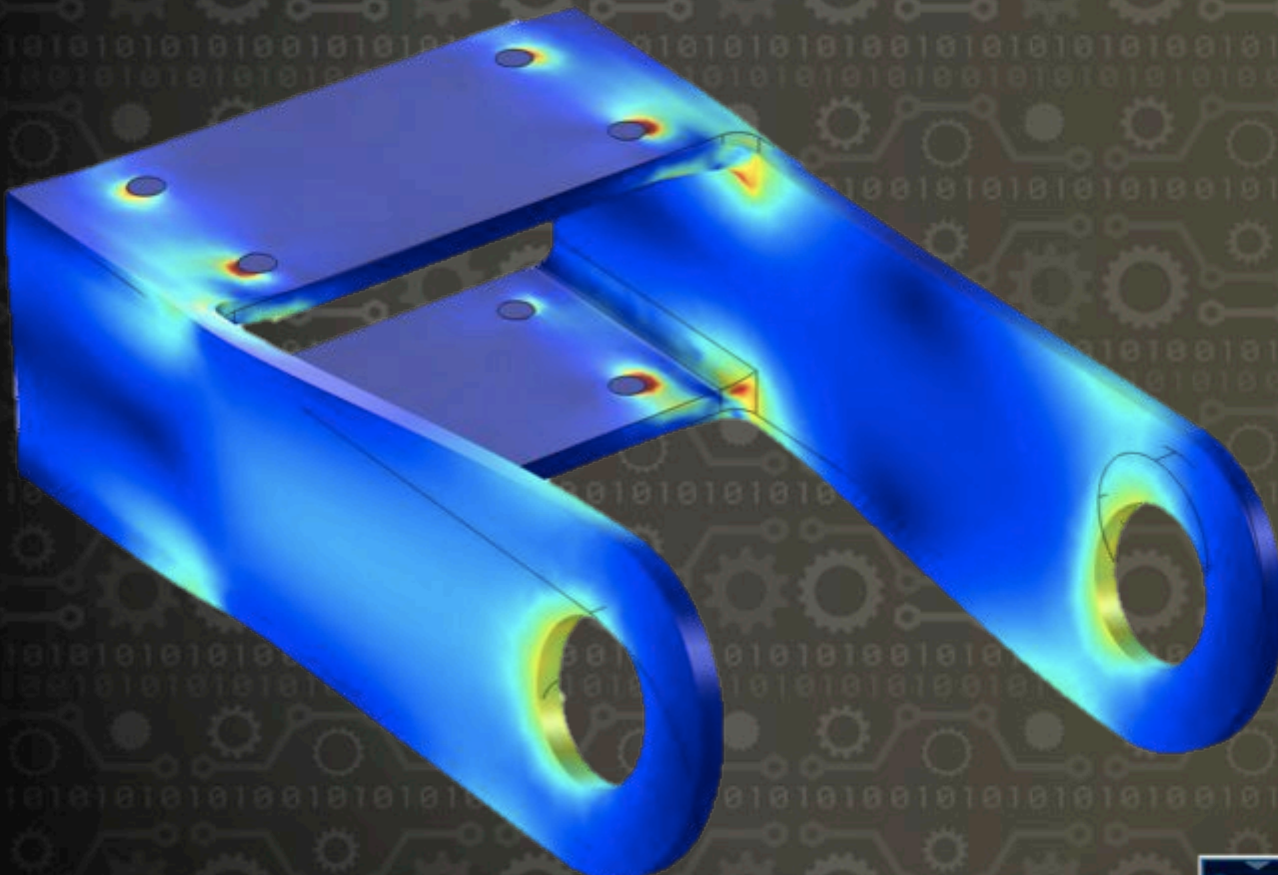
SIMULATION BASED CONCEPT DESIGN:

SETTING THE RIGHT CONTEXT FOR DETAILED DESIGN



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SIMULATION BASED CONCEPT DESIGN

The concept behind Simulation Driven Design has always been sound.

The idea is to base engineering decisions on the results of simulations. By following this practice progressively through the development cycle, the design is continuously verified. Prototyping and testing transform from a costly iterative process to a final verification and validation step. The result is savings in terms of budget and costs.

Adoption of Simulation Driven Design initiatives started in the detailed design phase. The simulation process started with the 3D model created in Computer Aided Design (CAD) applications. Such initiatives met success by refining and tweaking existing design ideas. However, some organizations started to come to a realization: by the time the design was being modeled in a CAD application, most of the major engineering decisions had already been made. To truly leverage simulation for a larger impact, it must be used earlier than detailed design, in the concept design phase.

Only recently have organizations started to pursue Simulation Driven Design in the concept design phase. And in fact, many organizations still face outstanding questions with respect to their efforts. What are the biggest barriers and how can they be overcome? Who should be the key role to enable such activities? What practices are or are not impactful? To date, there has been little empirical evidence pointing to proof one way or the other.

That, in short, is one of the objectives of the 2013 Simulation Driven Design study. Conducted by Lifecycle Insights, the study's survey collected 1,005 responses with respect to the goals, challenges, practices and adoption of technology for three simulation topics: concept simulation, detailed design simulation and simulation management.

This eBook reveals the findings related to concept simulations from that study, explaining and putting them into context. Specifically, it details the study's findings related to the impact of failed prototypes, the top organizational objectives for conceptual simulation, the biggest challenges of conceptual simulation and the integration of CAD applications in the simulation process. Furthermore, a review of several recently introduced simulation technologies and their potential impact are included.

Simulation Driven Design initiatives have delivered part of the value promised by the original vision. However, unrealized value still remains in the application of conceptual simulation.

The Outcomes of Failed Prototypes

When prototypes fail in testing, there's plenty of fallout both for the organization and the individual. But findings from the study reveal that for those conducting conceptual simulations, there are three predominant issues that arise.

- **Missed Project Milestones:** When prototypes fail, delays are introduced in the project schedule. Executives then shift engineers from other projects and require longer hours, reprioritizing their work, in an effort to get back on track. When prototypes fail in testing late in the design cycle, there is little opportunity to meet design release or other milestones in the development schedule. As such, failed prototypes represent a more significant risk.
- **Extra Rounds of Prototyping or Testing:** The second most frequently cited issue represents hard dollar expenses. Materials and equipment are required to build new prototypes. Extra time in external testing facilities cost real money as well, especially for more specialized and unusual tests. Failed prototypes also carry a cost in terms of time as well. That's time that could have been spent on other downstream activities or new product development projects.
- **Working Late and on the Weekend:** The third predominant issue is very personal in nature for engineers and designers. Of course, executive leadership cares insofar as concerns for personnel attrition will carry them. For engineers and designers, extra time spent at work is time taken out of their personal lives.

Ultimately, this set of findings is all about when an organization uncovers design problems. If it is when a prototype fails, obviously the engineering organization experiences serious issues as a result. Finding and resolving such design problems in the detailed design phase is preferable because the organization can avoid scrambling to fix the issue during testing. The challenge is that, even during the detailed design phase, constraints and requirements can limit the design options available to fix the design problem.

The most valuable time to catch such issues is early during concept design. When such design problems are caught so early, designers and engineers have more flexibility to fix them.

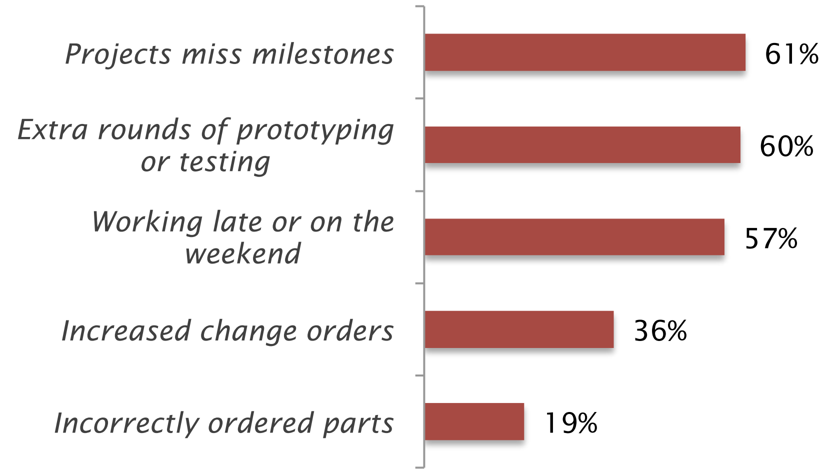


Figure 1: Top Outcomes of Failed Prototypes

Findings from the 2013 Simulation Driven Design Study, filtered by those conducting conceptual simulation, totaling 730 respondents

Business Goals for Conceptual Simulation

The pursuit of concept simulation is a separate additional effort for organizations. A key issue in that context is to understand the objectives organizations hope to achieve from their efforts.

- **Addressing the Outcomes of Failed Prototypes:** The top objective for conceptual simulation is simple: address the issues caused by failed prototypes. Organizations are seeking to curtail these issues by simulating performance early, providing them the opportunity to make broader changes to the design, or even change operating constraints or requirements.
- **Reducing Recurring Costs:** Two of the goals for conceptual simulation in the second tier relate to product and lifecycle costs. In the conceptual stage, organizations can perform trade-offs to understand how they perform differently, reduce the amount of material or manufacturing effort, as well as avoid warranty, service, and quality costs.
- **Contract and Regulatory Obligations:** Another goal in the second tier is to satisfy contractual obligations or meet regulatory requirements. These efforts are part of attempts to win business during contractual bidding or selling processes. Such activities spur confidence not only in the proposed design, but also in the organization.

The takeaway from these findings is that organizations recognize the value that concept simulation can deliver, and are pursuing related initiatives to achieve these business objectives.

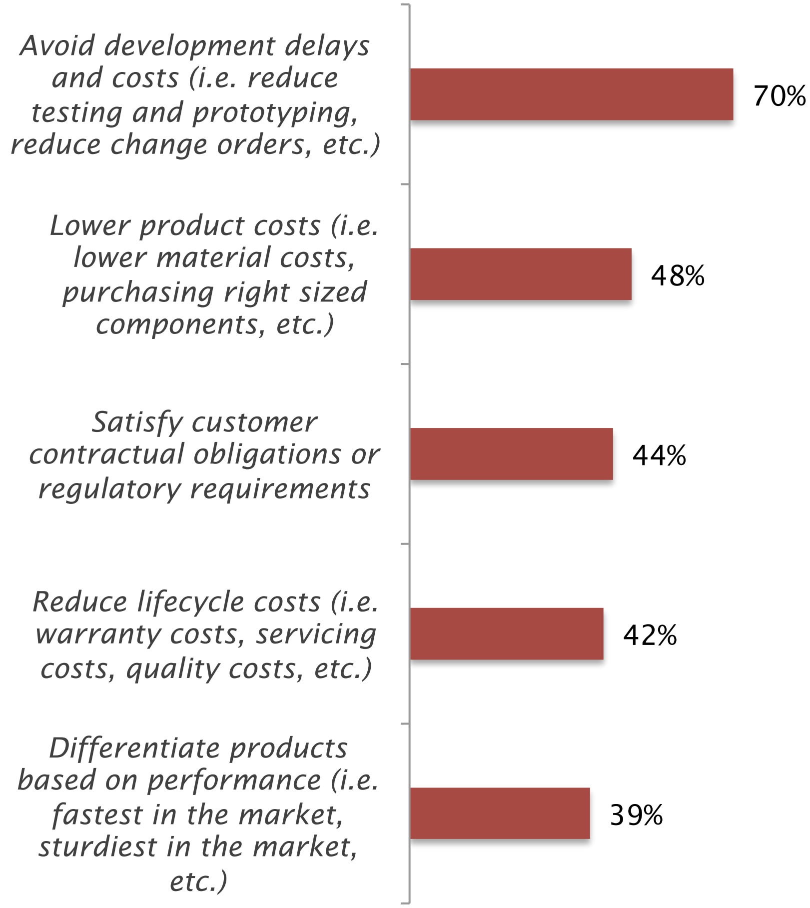


Figure 2: Top Business Objectives for Concept Simulation

Findings from the 2013 Simulation Driven Design Study, filtered by those conducting conceptual simulation, totaling 730 respondents

Challenges to Simulation Concepts

When it comes to the obstacles that hinder conceptual simulation, there is no single predominant issue. In fact, there were six answers in the study that more than 50% of the respondents cited. While there is no one challenge to blame, there are some that fit together.

- **There is Never Enough Time:** Simulation analysts don't have enough time. Engineers don't have enough time. The simulation process takes too much time. Time is actually a common obstacle for almost every initiative within an organization. Processes, procedures, practices, and technologies that reduce the time requirements on stakeholders in design are particularly useful.
- **The Right Geometry and Mesh:** Another issue more specific to conceptual simulation is the difficulty in creating or finding representative geometry for the concept design. The details behind this issue lie in the specific practices used for conceptual simulation, which will be covered in the next section. The other challenge lies in generating a simulation mesh. Too loose of a mesh does not generate accurate results. Too fine of a mesh uses more compute resources during the simulation's solve. Given that time is already a precious resource, it is important to strike the right balance.

Time will always be a challenge when organizations pursue new initiatives. Fortunately, numerous enhancements for analysis technology in recent years have focused on making it easier and faster to conduct simulations in the concept and detailed design phases. This will be an area of improvement in the coming years.

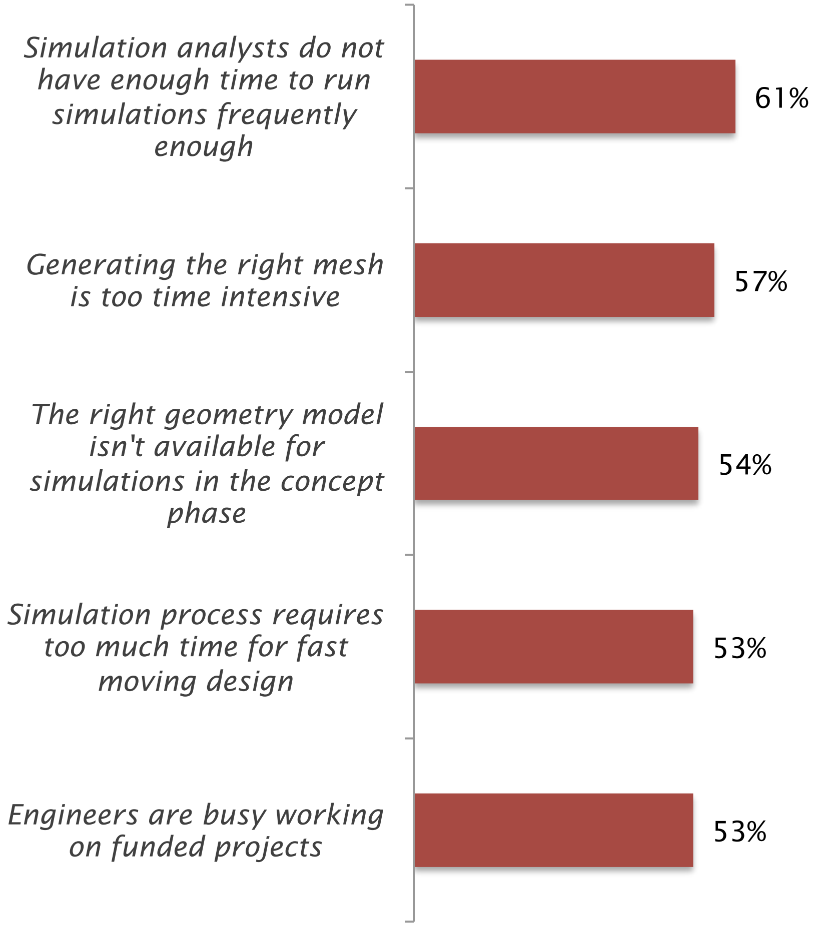


Figure 3: Top Challenges to Conducting Conceptual Simulation

Findings from the 2013 Simulation Driven Design Study, filtered by those conducting conceptual simulation, totaling 730 respondents

Tactical Execution of Concept Simulation

The business objectives for conceptual simulation are important, but it is just as critical to understand how those simulations are used in the design cycle today. In this section, we'll explore the application of concept simulations as well as the tactical practices that are used to conduct concept simulations.

Applications of Conceptual Simulations

Simulation results can be used in a variety of ways in the concept design stage. Findings from the study show many organizations are using them to drive decisions, but some are going above and beyond that.

- **Simulation Driven Decision Making:** The most frequently cited application of conceptual simulations is to select or improve designs. This speaks to the practice of exploring and iterating on design concepts while checking performance along the way. Engineers and designers compare and contrast different ideas to see which ones fulfill their functional needs most completely.
- **Enterprise Trade-off Studies:** The comparison of different concepts isn't the only application for conceptual simulations. A smaller portion of organizations is using results to engage non-engineering stakeholders in trade-off studies. These organizations gain insight into the impact of design changes on aesthetic traits as well as manufacturing difficulty and costs.

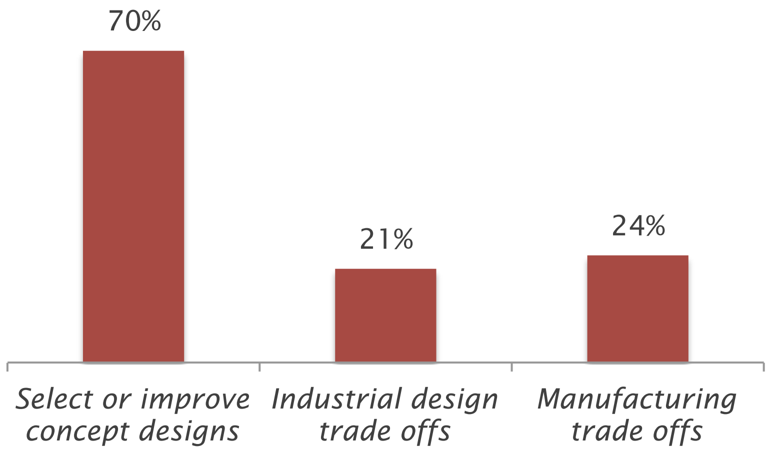


Figure 4: Design Applications of Concept Simulation

Findings from the 2013 Simulation Driven Design Study, filtered by those conducting conceptual simulation, totaling 730 respondents

Practices Employed in Conceptual Simulation

As noted in the prior section, one set of challenges to conducting conceptual simulations is getting the right geometry to represent the design idea as well as generating the right mesh to attain accurate simulation results.

The issue with the first challenge not only lies in representing the concept, but also taking abstractions and simplifications into account to functionally represent the design idea. To that end, organizations have tried a few different approaches.

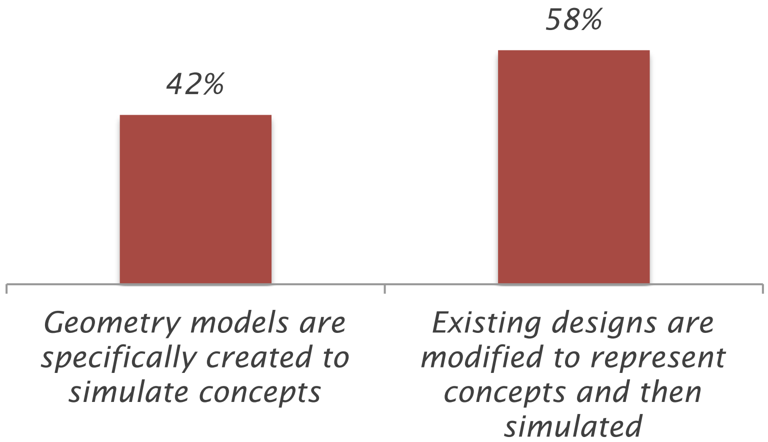


Figure 5: Approaches of Representing Concept Geometry

Findings from the 2013 Simulation Driven Design Study, filtered by those conducting conceptual simulation, totaling 730 respondents

Simulations are conducted with CAE software independent of CAD or imported 3D models	39%
Simulations are conducted with CAE software that imports CAD or 3D models	62%
Simulations are conducted with CAE and CAD software that pass changes back and forth	23%
Simulations are conducted completely within CAD software	21%

Table 1: Interaction between CAD and Simulation Software

Findings from the 2013 Simulation Driven Design Study, filtered by those conducting conceptual simulation, totaling 730 respondents

- **Creating Conceptual Simulation Geometry:** One approach is to create new geometry representing the design idea. The geometry can be a 3D model, but it can also be 2D sketches. Also, it is important to understand that organizations are creating simulation specific geometry, not conceptual geometry that is then transformed into something suitable for simulation.
- **Repurposing Detailed Design Geometry:** The other approach is to take existing detailed design 3D models and attempt to transform them into concept simulation geometry. This poses some risk as parametric feature-based models can be prone to failure. Users can spend inordinate amounts of time fighting such failures.

When it comes to the integration of CAD into the simulation process during the concept stage, it is notable that many organizations are using 3D models only as a starting point for simulations. Few organizations are iterating back and forth between CAD and Computer Aided Engineering (CAE) software tools, or using integrated CAD-CAE offerings. These findings are important because 70% of the study's respondents cited that they use simulation results to select or improve concept designs, which implies the need to iterate and explore new options while assessing product performance.

New Technologies for Concept Simulation

The findings from the 2013 Simulation Driven Design study paint an interesting story for concept simulation.

- Overall, 82% of the study's respondents are conducting conceptual simulation.
- The top business objectives that organizations have for conceptual simulation is to mitigate the outcomes of failed prototypes.
- Time is an obstacle hindering conceptual simulation, but little can be done in this area.
- Generating concept geometry for concept simulation is also a hindrance, with more than half of the study's respondents citing that they repurpose detailed designs for conceptual simulation.
- Furthermore, over 60% only use 3D models as the starting point for conceptual simulation instead of an iterative integration between CAD and CAE.

In short, organizations are seeing value in conceptual simulation, yet many are attempting to apply practices and technologies from detailed design simulation, especially with respect to concept geometry. Such approaches are useful in refining and honing in on a specific detailed design, but are not as helpful when comparing and contrasting design concepts.

Fortunately, a number of new technologies have recently emerged that are directly applicable to concept simulation. The capabilities of these tools range from creating the right concept geometry to more automated improvement activities. Each offers some promise to advance the way conceptual simulation is conducted.

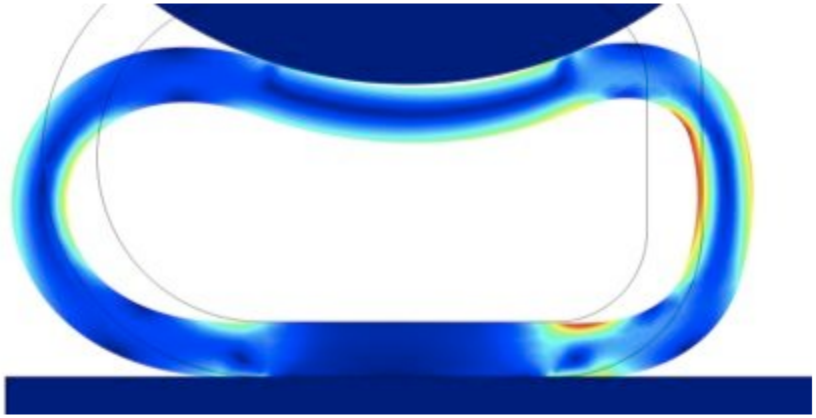
Emerging Geometry Manipulation Tools

Transforming an existing detailed design into a concept design with parametric features is dangerous, especially for non-CAD experts. Models with numerous features are prone to failure, which can take time to fix.

An alternative approach lies in sketching tools purpose-built for concept design. Such tools enable users, even those unfamiliar with CAD, to quickly develop complex sections and manipulate them easily. Overall, such tools allow fast iteration and exploration of new concepts.

An alternative lies in the emergence of Direct Modeling tools, which enable users to push and pull geometry directly instead of modifying feature dimensions. This allows even non-CAD users to bypass the complexity of feature-based models that are prone to failure.

When these two types of tools are combined with simulation capabilities, new design concepts can be built in a rapid fashion. This more directly supports the application that many organizations have in mind for concept simulation, which is to compare, select, and improve design ideas.



Topology Optimization

Another technology imminently applicable, yet new to concept simulation, is topology optimization. With this technology, a user first defines a design space, representing the volume within which a design can exist. This space could be as simple as a block or very complex, including swept blends, organic shapes or intricate surfacing. Next, the user defines loads and boundary conditions commonly associated with such analyses. Once initiated, the technology suggests different potential designs to satisfy the constraints.

In the past, this technology had incredibly complex controls. As a result, only extremely specialized users could apply the technology to design, frequently in the automotive, aerospace and defense industries. Much advancement, however, has been made in recent years to integrate it more closely into CAD applications. The result is that this once inaccessible tool is now accessible to non-simulation experts.

For concept simulation, the value this technology can provide is extreme. The technology provides new concepts to the user instead of merely simulating design ideas that the user generates. As a result, radically different concepts are generated, often ones that users would never have conceived. It is a powerful technology that can have a profound impact on conceptual simulation.


Original Design


Design Space


Loads and Constraints


Initial Ideal Design


Modified Ideal Design


Final Proposed Design

Summary and Conclusion

A wide range of issues related to concept simulation, including many findings from the 2013 Simulation Driven Design study, were covered in this eBook. Here's a recap of the most important points.

Outcomes of Failed Prototypes

The fallout of failed prototypes for organizations is serious. Missing project milestones, running extra rounds of prototyping, and working late or on the weekends all were cited by roughly 60% of the respondents in the study. These outcomes are disruptive for both organizations as well as individuals.

Business Goals for Concept Simulation

There was one predominant objective, avoiding development delays and costs, which was cited by 70% of the study's respondents. Organizations conducting concept simulations aim to mitigate the outcomes of failed prototypes. A second tier of goals including the reduction of product costs, lifecycle costs as well as the need to meet contract requirements and regulatory obligations were cited by roughly 40% of respondents.

Challenges to Concept Simulation

Three of the top five challenges to conducting concept simulation are related to time, which is a natural obstacle whenever organizations pursue new initiatives. The other two hindrances in the top five are related to creating the right geometry and mesh for concept simulation, hinting at issues in the execution of concept simulation.

Tactical Execution of Concept Simulation

Overall, 70% of organizations surveyed cited that concept simulation results were used to select or improve design ideas. Yet over 60% only use 3D models as the starting point for conceptual simulation, proof that they are starting simulation too late in the design cycle. More iterative integrations between CAD and CAE were cited at less than 30% each.

Emerging Tools for Concept Simulation

New tools that promise easier concept simulation are emerging. New 2D sketching tools and Direct Modeling combined with simulation allow the quick exploration of new design ideas. Topology Optimization suggests new designs that meet constraints, often generating concepts users may never have conceived. These advances have made simulation accessible to non-experts.

Organizations are recognizing the value that concept simulation can provide. New emerging technologies promise yet more value in the near future.

For more information on Conceptual Simulation, please visit solidThinking's site. Underwritten in part by solidThinking, Inc. all concepts and ideas developed independently, © 2013-2014 LC-Insights LLC.

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