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Tech-Clarity Insight:

The Business Value of Simulation

Saving Time and Money, and Getting Products Right the First Time

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Executive Overview

Over the last few years, manufacturers have focused on surviving the down economy and preparing to prosper as markets recover. Most have reduced cost and are running very lean. But as Tech-Clarity's *Engineering's Role in Surviving a Down Economy* research reports, cutting costs can't result in cutting quality in competitive markets. Engineers today need to get innovative products to market quickly to gain as much of an advantage in the market as they can, while reducing product cost and maintaining product quality.

Simulation allows companies to meet the demands for reduced cost and faster time to market, but without compromising product quality.

One strategy that is providing value in this environment is digital design validation using simulation technologies. Simulation allows companies to meet the demands for reduced cost and faster time to market, but without compromising product quality. "*In the past, we ran more physical tests*," explains Dr. Tayeb Zeguer, Principal Tech Specialist for automotive manufacturer Jaguar Cars Ltd. "*But we can't afford that anymore. The budget was very high, but the value to engineering was very low*."

Beyond cost reduction, simulation helps companies raise the bar on their products. Simulation can help companies gain better insight and understanding of the physical behavior of their products than testing ever could. It also helps them innovate, allowing the freedom to test new concepts with confidence. Whether they are optimizing for weight, material reduction, and cost or testing new innovative concepts, early simulation helps manufacturers explore and learn from more design iterations.

In years to come, simulation and digital prototyping technology are going to be as essential as CAD is to design products.
James F. Amero, Global Engineering Sr. Systems Analyst, Joy Mining Machinery

To apply simulation early and often, companies are changing the way they develop products so that simulation processes and tools are part of the design and engineering process. "*In years to come, simulation and digital prototyping technology are going to be as essential as CAD is to design products*," explains James F. Amero, Global Engineering Senior Systems Analyst for Joy Mining Machinery. To accomplish this, manufacturers are making simulation technology accessible to their design engineers in addition to simulation experts.

This report finds that manufacturers are finding significant business value from simulation. As Dave Smith, Director of Engineering for agricultural equipment producer Unverferth Manufacturing Company says, "*The more we can simulate the better we become*." Given today's economy, simulation just makes good business sense.

Product Development Challenges

Manufacturers today are facing significant product development challenges. The challenging, global economy has increased competition and driven prices down. At the same time, many are facing rising material costs. These factors mean that building products with extremely high safety factors and simply making things bigger and heavier will no longer suffice. But quality expectations have not been relaxed, if anything they have increased. This puts more pressure on engineering organizations that are already running lean. As Jaguar's Dr. Zeguer describes, "*We are in business to make a profit. Profit comes from making a great product that the customer wants to buy. But the car business is very competitive, so we must also make the product faster, at a reduced cost, and with reduced warranty expense. .*" Not an easy set of objectives.

Building products with extremely high safety factors and simply making things bigger and heavier will no longer suffice.

At the same time, products are becoming more complex as discussed in Tech-Clarity's *The Five Dimensions of Product Complexity*. Partially due to the high cost of traditional materials, manufacturers are moving to new materials such as plastics and composites. These materials are harder to predict during design because engineers have less experience using them. Even purely mechanical products have become increasingly complex. Unverferth's Smith describes one such scenario, requiring new design techniques. "*We were developing a cultivator that we didn't think was going to be practical, but got into the modeling and worked out the details and it came around. We wouldn't even have it to the market in that timing without simulation*."

Complexity is leading more companies to utilize simulation to predict how products will behave in the real world.

Unfortunately, increased complexity is not limited to the products themselves. Manufacturers are also adopting more complex manufacturing processes. For example, injection molding requires an understanding of the interaction between plastic temperature, mold temperature, pressure, injection time, and other parameters. These factors impact product quality, cost, and cycle times. Even plastics are getting more complex with materials that include fibers that are directionally sensitive. This complexity is leading more companies to utilize simulation to predict how products will behave in the real world.

The Economics of Simulation

Of all of the advantages that lead companies to increase the use of simulation, perhaps the most obvious one is cost reduction. As research for Tech-Clarity's *Innovating Through an Economic Downturn* explained, reducing the cost of a product can't come at the expense of creating products that are perceived as "cheap." Regardless of increased complexity, products have to work. But the old approach of building prototypes and physically testing them is simply too expensive. "*We used to make things, break them, and then try again*," Dr. Zeguer of Jaguar explains. "*Economically we just couldn't sustain that behavior by engineers*."

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Physical prototyping is very costly, as is physical testing. These processes consume valuable time and resources. Let's look at an example from Unverferth, which describes the cost of prototyping relatively inexpensive agricultural equipment. "*A prototype will run about three times the cost of the production product, sometimes even higher*," explains Dave Smith. "*One prototype will run $50-60k. If we are able to iterate designs and change them electronically, eliminating physical prototypes, we can save $100k pretty easily*." Moving tests to a virtual environment through simulation saves time and money. Even if testing is required due to industry standards, simulation can help to assure that tests, particularly third party testing when required, are only done once. "*We have moved from purely physical testing to extensive digital testing followed up by final physical testing*," commented Joy Mining's Amero. "*Now 'test it' means simulate in the virtual environment.*"

One prototype will run $50-60k … we can save $100k pretty easily.
Dave Smith, Director of Engineering, Unverferth Manufacturing Company

Cost savings are not just limited to direct savings from reduced physical prototypes and testing. A mistake in a product could cost millions in warranty costs. Even a mistake caught late in the design process can cost a lot in engineering changes. For example a mistake that requires a change to tooling or a mold could cost hundreds of thousands of dollars to correct. "*We save nearly a million dollars a year by avoiding retooling and other issues,*" describes Dr. Zeguer of Jaguar.

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Getting the Product Right the First Time

Manufacturers can't afford to get products wrong. Quality problems impact company reputation, add cost, increase warranty expenses, and lead to scrap and rework in the plant. Digital prototyping and simulation help find errors early, whether it is something straight-forward like motion simulation or something more mathematically complex like stress, vibration (modal), thermal, or flow analyses. Simulation is an integral part of digital prototyping strategy. "*We digitally prototype everywhere from checking clearances and interference to putting subassemblies together, to how it will operate in its environment*," describes Joy Mining's Amero, "*We prototype the movement and interactions, and then simulate to understand the stresses and strains to see how it will actually work underground.*"

A "build it, break it, fix it" approach doesn't provide enough insight into why a product failed.

Beyond cost, a "build it, break it, fix it" approach doesn't provide enough insight into why a product failed. In addition, physical testing frequently finds the "weakest link in the chain" but does not identify additional issues until the next iteration. "*We used to just build a prototype by guessing based on experience, test it, build it again, and repeat that three to four times*," comments Unverferth's Smith. "*Now, we are pretty much down to one go-around on the prototype*."

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Dr. Tayeb Zeguer, Principal Tech Specialist, Jaguar Cars Ltd.

Physical prototypes are not only too costly, they are also too slow. To develop products right, early insight is the key so changes can be made before design decision such as materials are locked in. With simulation, this trial and error approach is replaced with more rapid iterations that provide detailed insight into the underlying physics. "*Simulation not only identifies the problem, it tells you what you can do to fix it*," describes Dr. Zeguer of Jaguar, "*When we use simulation simultaneously with the design, we can get it right the first time and eliminate very costly issues later on*." A simulation can be better than a physical test, because it can show you why the part failed and give you suggestions to fix it. For example, an injection molding simulation provides the ability to "see inside" the mold, something you can't do with a prototype regardless of how much time and money you put into it.

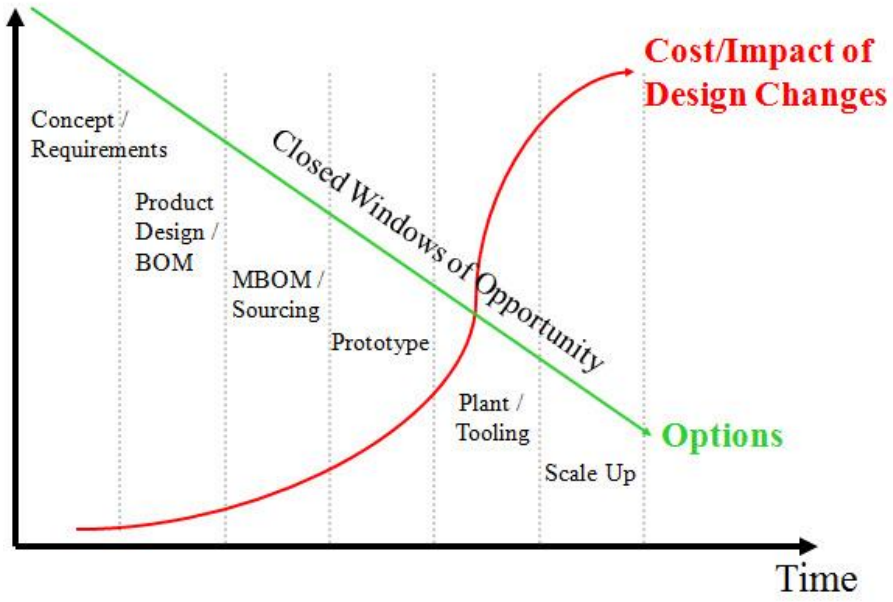

Figure 1: Closed Windows of Opportunity

Again, the key is to find failure modes early. Once you find them, you can fix them. What typically drives poor quality and high costs are late surprises that force poor tradeoffs and compromises (Figure 1). Simulation helps get the product right when there is still time and flexibility to address issues. Of course most companies still do some physical testing, if nothing else to increase their confidence in their simulation results.

Raising the Bar on "Right"

Getting the product "right" typically means preventing product failure. This is more challenging as large safety factors and extra material are becoming a luxury. But how can manufacturers know how overdesigned a product is, or how big of a margin of safety they are providing? Physical testing can predict that the product is safe, but at what cost? "*A trial and error approach is lengthy, expensive, and the solution is not optimized,*" says Dr. Zeguer of Jaguar, "*You need simulation to make tradeoffs and optimize products for weight and performance*."

The toughest part of our job is balancing quality with cost.
Dave Smith, Director of Engineering, Unverferth Manufacturing Company

Moving from making sure a product won't break to optimizing for weight, material, cost, and performance requires much better insight into product behavior. "*The toughest part of our job is balancing quality with cost*," says Dave Smith of Unverferth. "*It needs to be structurally sounds with the least amount of material. That is why we like finite element*

analysis (FEA) simulation to validate designs early." Simulation gives insight into product behavior that allows engineers to optimize confidently. Reducing materials can also help with environmental impact, requiring less natural resources and also potentially requiring less energy to produce and operate.

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Digital prototyping and simulation can also help stimulate innovation. One way this happens is by simply allowing for more design iterations. "*We haven't cut steel in real world, but we have cut in the simulation tool 100 times and haven't destroyed anything*," explains James Amero of Joy Mining. Without simulation, most engineers will play it safe with their designs. They can't afford to try radical new ideas because of the time and expense of physical prototyping. But as Unverferth's Dave Smith notes, "*A digital prototype is much easier to manipulate than the actual iron*."

With simulation you get fast evaluation of design alternatives and you can do a lot of iterations quickly. It helps you really explore more of the design space.
Dr. Tayeb Zeguer, Principal Tech Specialist, Jaguar Cars Ltd.

Digital prototypes offer rapid iterations at little cost so engineers are free to explore more design options and try "crazy" ideas that might just be the next breakthrough design. "*Simulation helps you optimize designs, you can't do that with a test because you can only do it once*," says Jaguar's Dr. Zeguer. "*With simulation you get fast evaluation of design alternatives and you can do a lot of iterations quickly. It helps you really explore more of the design space.*" It is hard to introduce a quantum change in a product when you stray from physical experience. Radical design changes like reducing the weight 50% or increasing strength "3X" require more validation. "*That's what makes it fun, we can try our ideas and not rely on tried and true techniques*," explains Unverferth's Smith. "*Now, you are just talking about a couple of hours or a couple of days, so you can explore things you just wouldn't have even tried*."

Baking Simulation into the Design Process

Finding problems early in the design process gives you time to react. "*All groups are responsible for performing some simulation*," explains James Amero of Joy Mining. "*Wherever possible, we have the engineer simulate because the further back you find a mistake, the less costly it is.*" Engineers can apply simulation as early as the conceptual mockup level to test out ideas before investing in a full design or rigorous validation.

If engineers can test their own ideas, they can iterate rapidly and innovate more. Dr. Zeguer explains this is what they have done at Jaguar, "*Today, simulation is implemented very well into the design process itself*."

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Tools are available for experts that want to control every aspect of a simulation, but for others there are now simpler, wizard-based solutions. These solutions mask the complexity from the engineer, providing the power of simulation to more engineers. Although the interface is simpler, tools still employ powerful analytics including self-checking to ensure mesh approach is suitable. In addition, graphical results make it easy to interpret and communicate results. These simpler tools are not meant to replace the tools that allow full manipulation of meshes and parameters that a simulation expert would use. Instead, they are intended to add new simulation capabilities directly into the design process, speeding up designs while improving decision-making and resulting quality. As Dr. Zeguer explains, "*Engineers are always making critical decisions, when you apply simulation it makes them more effective*." Engineers make decisions every day based on experience and gut feel. Tightly integrating simulation tools into product design introduces additional science to the process and helps improve engineering decisions.

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In fact, embedded solutions aren't meant to replace the expert. They are meant to add simulation earlier into the process where today there is frequently none. "*From an engineer's perspective, the more you can do in the virtual environment the less likely that somebody is going to come back and bring you a problem*," comments Joy Mining's Amero. Tools are being embedded into the CAD environment, making them a more natural part of the design process and reducing the need to recreate or convert models. This allows access by more engineers. "*We are planning to do intermediate simulation and FEA, which will enable individual designers and engineers during design phases and not overburden our specialists*," Unververth's Smith explains. "*We can take our CAD models straight into the simulation software without tremendous tweaking and can start to perform necessary tests*."

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Of course additional simulation by engineers is not a substitute for expert analysis. In fact, early simulation by engineers should be viewed as freeing up specialists for more valuable simulation activities. But companies can't change all at once. "*Don't do everything by simulation*," advises Dr. Zeguer of Jaguar. "*Try to gradually replace everything that could be tested by simulation on a selective basis*." Mr. Amero of Joy Mining echoes this advice. "*Over time, simulation results are backed up by real-world experience that proves that it worked. We used it in different scenarios and it worked really well, then we looked to expand into other areas*."

Conclusion

Companies need to develop products faster, with lower cost and better quality, using fewer resources. "*Our biggest goal was to shorten time to market*," explains Dave Smith of Unverferth. "*Before simulation, we would start to cut corners. We looked for ways to prevent that, which is where simulation came in. Now we can shortcut the process, but still keep the quality*." Time is a critical element of competition in today's markets. "*Time to market is really an advantage*," Smith concludes. Simulation helps companies reduce cost and design cycles, allowing more iterations and faster time to market. "*Our drivers were really cost, performance, and speed to market*," recalls Jaguar's Dr. Zeguer. "*In a competitive market, we need to get there very fast with minimal issues. Simulation has been a big advantage – reducing cost and increasing profit margins.*"

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Reducing physical prototypes and testing saves time and money. In fact, most companies can financially justify the investment in simulation technology through cost savings alone. But there are also more strategic benefits. "*It is definitely a value to the business to use simulation technology, and will continue to grow over time*," concludes Joy Mining's Amero. "*Simulation technology has helped us improve product performance and safety*."

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Simulation not only saves time and money, it opens up the opportunity for optimization such as reducing product cost and weight. It can also help improve sustainability. "*Our business priority is robust verification with fewer physical prototypes*," Dr. Zeguer of Jaguar explains. "*It improves engineering efficiencies and reduces product development time, but could also achieve sustainable simulation operations and reduce CO_2*

emissions." Simulation gives engineers a "safety net" to try more innovative ideas, and enables engineers to make better decisions.

Baking simulation into the design process and making the tools accessible to engineers in addition to experts offers the ability to find issues earlier, and innovate more.

Baking simulation into the design process and making the tools accessible to engineers in addition to experts offers the ability to find issues earlier, and innovate more. "*For engineering, it needs to be easy to use so each person can use it*," states Unverferth's Smith. "*It is critical to building an economical product with an acceptable cost*." Of course companies should not look at simulation as turning off engineering intuition and experience, but adding a deeper understanding and insight to increase design confidence. "*Customer demands are higher, but investment and margins are lower, so you have to use the right tools to be competitive*," sums up Dr. Zeguer of Jaguar. "*Simulation is the one tool that keeps us competitive and in the market. Simulation is an engineering tool that should be part of the design process and part of the business strategy*."

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Recommendations

Based on industry experience and research for this report, Tech-Clarity offers the following recommendations:

- Simulate to replace physical prototypes and find issues early
- Get more insight into product behavior than physical prototypes can offer with simulation
- Move from "build-break" to more rapid, digital prototyping iterations
- Step up "right" in "getting the product right the first time" – optimize products for cost, weight, and performance
- Allow engineers to innovate through rapid iterations and quick feedback on new concepts
- Integrate simulation into everyday engineering workflows
- Free up simulation specialists for higher value work such a final validation and complex problem solving

About the Author

Jim Brown is the President of Tech-Clarity, an independent research and consulting firm that specializes in analyzing the true business value of software technology and services. Jim has over 20 years of experience in software for the manufacturing industries, with a broad background including roles in industry, management consulting, the software industry, and research. His experience spans enterprise applications including PLM, engineering software, Digital Prototyping, ERP, quality management, service, manufacturing, and others. Jim is passionate about improving product innovation, product development, and engineering performance through the use of software technology and social computing techniques.

Jim is an experienced researcher, author, and public speaker and enjoys the opportunity to speak at conferences or anywhere that he can engage with people that are passionate about improving business performance through software technology.

Jim can be reached at jim.brown@tech-clarity.com, or you can find him on Twitter at @jim_techclarity or read his blog at www.tech-clarity.com/clarityonplm.