VIRTUAL PROTOTYPING VS. TRADITIONAL PRODUCT DEVELOPMENT METHODS

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Author: Greg Cline, Research Analyst
Manufacturing, Product Innovation & Engineering (PIE)

Report Highlights

Based on the experiences of over 170 respondents, this report explores how companies today are approaching New Product Development and Introduction (NPDI) and product simulation. Specifically, this report shows how Best-in-Class companies, who have turned to simulation and virtual prototyping, have outperformed their peers who still rely solely on traditional product development methods such as manual calculations or physical prototyping.

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Increasing product complexity leaves companies struggling to accurately predict the behavior of their products. As a result, Best-in-Class companies are turning to virtual prototyping software to arm their employees with the insight needed to develop and optimize today's products.

As companies struggle to competitively differentiate their products and beat their competitors to market, quick decisions within engineering have become increasingly critical to product success. These decisions can have a profound impact on three important factors for a product – speed of development, cost, and quality. Many have turned to simulation to help designers make effective decisions.

However, increasing product complexity leaves companies struggling to accurately predict the behavior of their products prior to physical testing. Hand calculations can no longer keep up with the needs of designers today, and physical prototyping is expensive and time-consuming. As a result, Best-in-Class companies are turning to virtual prototyping software to arm their employees with the insight needed to develop and optimize today's products.

New Products are Critical for Success

New products are the backbone for most organizations these days, as over a third of a company's revenue can be earned from these products. Of course, competitive pressures to successfully deliver them are high (Figure 1). To beat their competitors, companies must get their products to market quickly. In fact, Aberdeen's research has shown that the timely launch of a new product offers an organization the greatest opportunity for increased profitability. Designers also need efficient methods for making better decisions to improve quality, while keeping their products economical.

At the same time, companies need a better understanding of product behavior to enable the innovations that will create market opportunities for new revenue streams. But as innovation is increased within a product, so too is the complexity of designing

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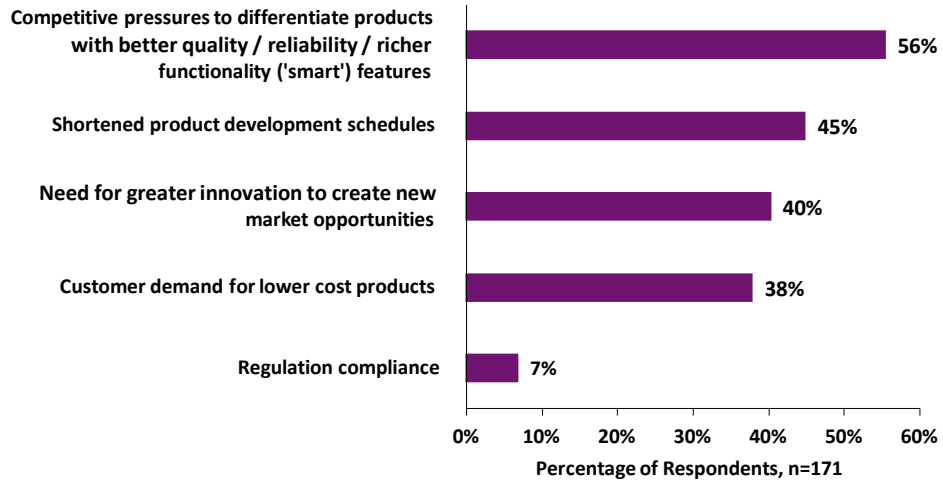
that product. This push to more innovative and complex designs helps to differentiate products from competitors; it also results in designers being forced to make trade-offs between speed, cost, and quality.

*NPDI - New Product Development and Introduction

Figure 1: Balancing a Multivariate NPDI* Equation



Source: Aberdeen Group, May 2017

Top Challenges for Product Development

Respondents were asked to select their top two product development challenges:

- Competitive differentiation is becoming more difficult - 50%
- Products are becoming more complex - 37%
- Limited development resources - 38%
- Products operating in varying and complex environments - 29%
- Lack of tolerance in design flaws - 8%

Effectively balancing these factors is much easier said than done – trying to achieve this equilibrium has many challenges itself (see sidebar). Complexity is, by far, the overwhelming challenge felt by companies today when trying to develop new products – making it harder to evaluate the impact of different design alternatives. This complexity is across the board as well; no matter the industry, products are becoming increasingly elaborate in their use of mechanics, electronics, and embedded systems.

Defining Best-in-Class Product Developers

To identify best practices for product development, Aberdeen measured participants' ability to meet product launch dates,

quality targets, cost targets, revenue targets, and change in development time. Aberdeen categorized participants as Best-in-Class (top 20% of performers) and All Others (Bottom 80% of performers). Table 2 summarizes the aggregate performance of each category.

Clearly, the Best-in-Class have much tighter control over their products. Even in the face of all the challenges and roadblocks mentioned earlier, these companies are able to put out high quality products, at a low cost, within the intended timeframe. Also, the 29% reduction in development cycles plays a huge role in the continued success of the Best-in-Class, as shrinking development schedules is still the top pressure felt by all.

Table 1: Top Performers Earn Best-in-Class Status

Definition of Maturity Class	Mean Class Performance
Best-in-Class: Top 20% of aggregate performance scorers	76% of product launch dates met 29% decrease in length of development cycle over the last two years 71% of product cost targets 77% of product quality targets met at design release 74% of product revenue targets met
All Others: Bottom 80% of aggregate performance scorers	65% of product launch dates met 5% decrease in length of development cycle over the last two years 63% of product cost targets 74% of product quality targets met at design release 67% of product revenue targets met

Source: Aberdeen Group, May 2017

This all points back to the same goal: determining product behavior by verifying product design as soon as possible. It is no surprise then to see that 75% of Best-in-Class companies have a strategy in place to improve this process. But that is easier said than done. How are the Best-in-Class successfully executing this strategy?

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Top Challenges of Physical Prototypes

- Time required to build physical prototype – 65%
- Cost required to build physical prototype – 65%
- Multiple iterations of prototypes needed – 50%
- Time required to test physical prototype – 40%
- Limitations in the testing that can be performed on a prototype – 31%
- Performance of prototype does not match final product performance – 20%

The NPDI Lifecycle and Simulation

Bringing a product to market is a complex endeavor. There are many internal and external challenges throughout the NPDI lifecycle that can cause a product launch to fail. A major factor towards the success of a new product is an effective product design verification and validation (V&V) process. Companies that do not stress this phase of a product's lifecycle expose themselves to increased risks in product launch (poor quality, expensive recalls, costly product rework, or unexpected delays in product releases, an even increased liability). Simulation with virtual prototyping can be a powerful tool to optimize V&V for your products. Virtual prototyping has been integral to larger, more complex industries like Automotive or Aerospace & Defense. However, with the many benefits of knowing how a product will perform prior to testing, virtual prototyping is being adopted by an increasing number of SMBs across a broad spectrum of industries.

In general, there are three methods that designers use for predicting product performance:

1. **Building a physical prototype**
2. **Performing physics calculations by hand**
3. **Utilizing simulation with virtual prototyping software (FEA, CFD, etc.)**

Physical Prototyping

A physical prototype is an early model of a product built to test certain constraints or parameters. Prototypes are normally expensive to construct and time-consuming as well. Considering that multiple iterations of prototypes may be needed to get the

results you are looking for, it is easy to see how the overall waste can add up. There is also the physical constraint; you need to have the actual prototype built to begin testing, adding more time to the development cycle. As a result, physical prototyping is often the phase of a product's lifecycle with the most inefficiencies.

Hand Calculations

Performing stress calculations manually has been practiced for centuries, and most engineers are accustomed to this approach. Those who continue to utilize hand calculations are comfortable with what they know and feel it to be just as reliable and accurate as simulation tools; however, this is not the case.

The reality is that hand calculations are only simple, mechanical formulas that require broad assumptions and simplifications of multiple factors (geometry, tolerances, loading, etc.). Indeed, for everything but the simplest of part geometries, hand calculations are largely rough estimates of predetermined areas of concern. Also, collaborating and sharing these spreadsheets with other designers within the company can be challenging. This introduces further risk into the business if an employee leaves or a designer is working on an outdated version. Recheck processes can be long, and designers don't have time to spare.

Spreadsheets or hand calculations can work only on the most basic of products, where there is little chance for unintended consequences. As product complexity and safety / compliance mandates continue to increase, it is unrealistic for a manual approach to remain effective.

Virtual Prototyping Software

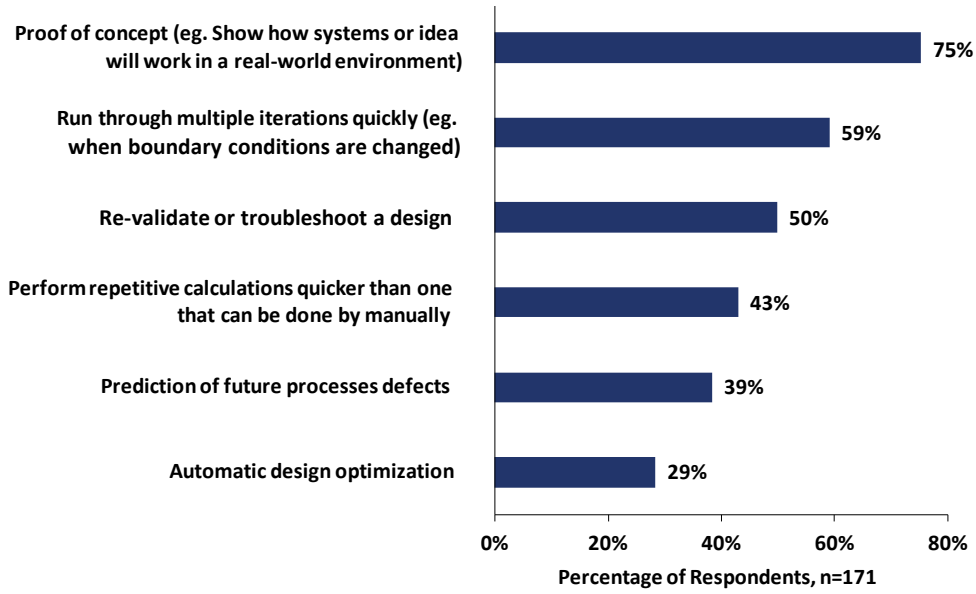
This leaves us with the third and final approach to predicting product behavior, simulation software with virtual prototyping.

Top Challenges of Hand Calculations

- Part geometries are becoming too complex for hand calculations – 61%
- Assumptions/simplifications required lower the accuracy of hand calculations – 55%
- Time required to perform calculations by hand – 42%
- Cannot optimize the cost / quality / performance of the design – 36%
- Hand calculations do not predict where failure will occur, only if failure will occur – 29%
- Difficult to collaborate with other designers – 20%

This is the method that 67% of Best-in-Class companies rely on for design validation and verification (Figure 2).

Figure 2: Why the Best-in-Class Turn to Virtual Prototyping



Source: Aberdeen Group, May 2017

"Manual calculations used to be relied upon more heavily in our company. Typically, these would have bigger factors of safety (FOS) applied due to the larger errors and less certain assumptions of these calculations. By switching to virtual simulation, we are now able to optimize our products for cost, quality, and performance."

~ Product Developer, Small Industrial Equipment Manufacturer

"A lot of power plants we work on are near the ocean, so over time the higher salt concentration in the air will accelerate corrosion. You need to be able to simulate operating conditions for 15 years or more down the line. Manual methods are too cumbersome to do this analysis, which is why virtual simulation is used."

~ Project Manager, BES&T

Virtual prototyping is the analysis or simulation of a product's behavior in a virtual environment, creating a virtual prototype of the product design. Its use is growing because there are more virtual prototyping options today than ever before. In the beginning, only specialists in large companies – mainly in Aerospace & Automotive industries – used simulation tools due to their complexity and cost. Next, design engineers only had the option of conducting basic linear static stress analysis. But in recent years, simulation tools have drastically evolved in their ease of use, intuitiveness, and depth of capabilities – including conditions like nonlinear static stress, dynamic stress (vibration), fluid flow, heat transfer, and FEA-based stress and motion

analysis. These capabilities can be combined to perform analyses that explore multiphysics scenarios as well.

Turning to software allows the Best-in-Class to develop virtual prototypes, which are used to predict performance of the entire system, prior to constructing their physical counterparts. Virtual prototyping provides the unique ability to look at the system as a whole and identify issues that may not have been foreseen. As a result, product time-to-market is reduced substantially, because virtual prototypes can be produced and tested much faster than their physical counterparts.

"We have been able to generate more ideas and test concepts because of virtual simulation. More product development opportunities now exist. Innovative products will be able to be moved through the development process quicker."

~ Research and Applications Engineer, Pentair Environmental Systems

Designers are also able to quickly explore the performance of numerous design alternatives without investing the time and money required to build physical prototypes or conduct hand calculations. This ability to analyze multiple alternatives quickly facilitates an important best practice: optimizing product designs.

The use of simulation with virtual prototyping is integral to a Best-in-Class company because of these benefits to NPDI, but how much of an impact does it have?

Breaking Down the Metrics and Performance

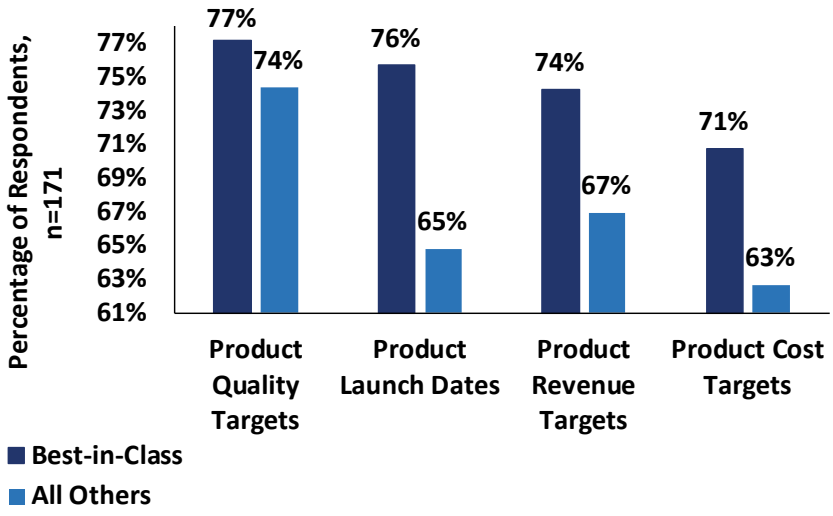
Figure 3 clearly shows that the use of simulation with virtual prototyping favored by Best-in-Class firms results in more successful products.

Best-in-Class firms easily outperform their peers in meeting product targets, and this success is directly attributable to their use of simulation and virtual prototyping over antiquated product development methods. Manufacturing and testing physical prototypes can also take up a significant amount of overall time and make product launch dates difficult to hit. However, because virtual prototyping software allows designs to be tested virtually, the dependence on physical prototypes can be reduced (Figure 4).

"Using simulation software early, combining more physics, and encouraging collaboration has reduced our development costs. It has also improved the performance of our initial prototypes. As a result, our products have greater assurance of reliability and durability."

~ Lead Mechanical Engineer, Sechan Electronics, Inc.

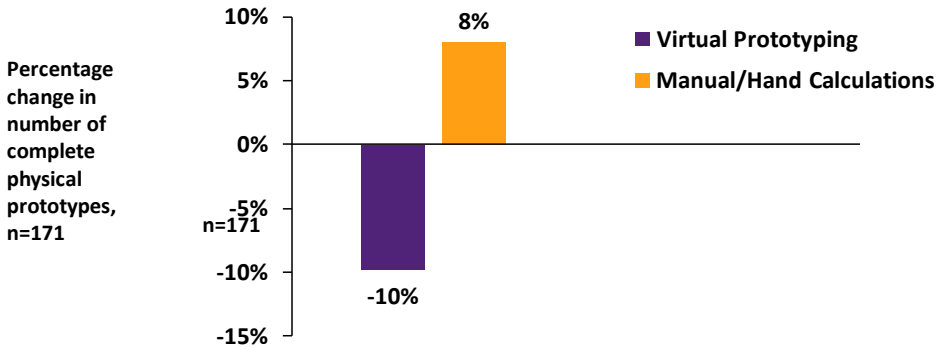
Figure 3: Are you Achieving your Product Targets?



Source: Aberdeen Group, May 2017

Ten percent fewer physical prototypes means more time savings, which can help bring a product to market sooner. Besides saving development time, using virtual prototyping software to verify your designs will also mean that you will be able to greatly reduce the costs of manufacturing and testing these physical prototypes.

Figure 4: Virtual Prototyping Reduces Physical Prototypes



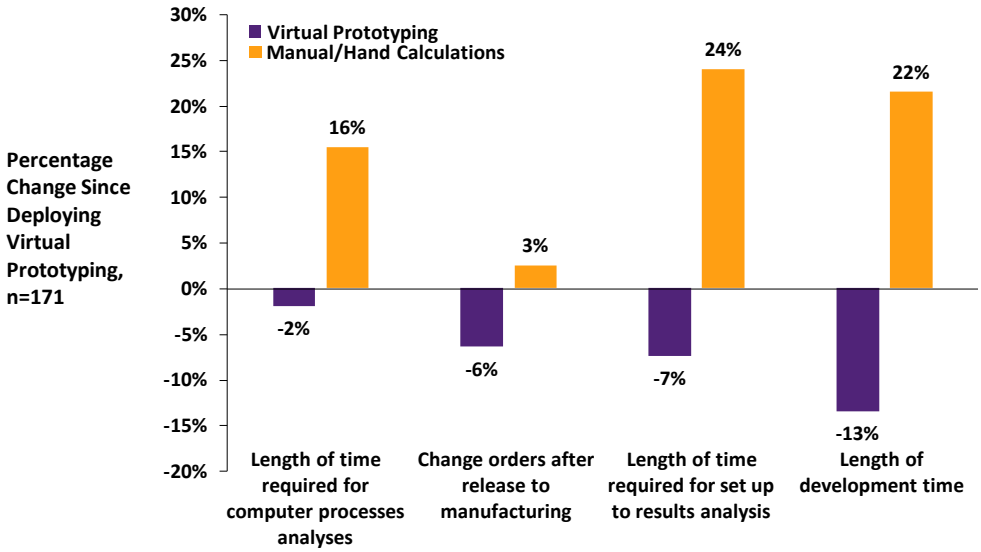
Source: Aberdeen Group, May 2017

"The more detailed models we are using are giving us a better understanding of our virtual prototypes. We are able to estimate the sensitivity of our products and define production tolerances accordingly. This helps a lot, not only during product development but also during [mass] production."

~ Product Development Engineer, GRANTE Antenna Development and Production Corporation

Backing up the fact that virtual prototyping is more reliable and accurate than hand calculations, or physical prototyping is what occurs after the product leaves designers' hands (Figure 5). Virtual prototyping users have seen a 6% decrease in engineering change orders (ECOs), while those relying on hand calculations have increased ECOs by 3%. What this means is that companies using simulation software are able to fix their designs before they get to production, unlike those utilizing manual methods, who fix their products afterwards.

Figure 5: Virtual Prototyping Improves Overall NPDI



Source: Aberdeen Group, May 2017

These reductions in rework can work wonders on overall product cost. Combine this with a product design that is already optimized for cost/quality/performance, requiring less testing, and it becomes clear why the Best-in-Class are 11% more likely to meet product cost targets than All Others. Faster product validation, fewer prototypes, and decreasing ECOs are perfectly reflected in the sharp drop in overall development time for virtual prototyping users. A 13% decrease in development time is the perfect way to

alleviate the top overall pressure designers feel today, thereby shrinking development windows.

Key Takeaways and Recommendations

Every company is looking to improve how they do business. It makes sense that companies who target their NPDI process are in a better position to succeed, as new products represent a company's largest potential for reward. However, NPDI also carries with it a considerable amount of risk; and improvement is not an easy task.

A great deal of success hinges on a company's ability to balance innovation, cost, time, and quality during product development. With tightening schedules, increasing complexity, and insufficient engineering resources, this balancing act can be a daunting task. Effectively doing so requires organizations to improve their understanding of product behavior as quickly as possible. There is good news, though; we can learn from the actions of the Best-in-Class, who have been successful in this challenging environment. The reasons for turning to virtual prototyping are simple:

- **Product complexity grows every day, manual methods cannot keep up with these new products.** As complexity increases, so does the difficulty in predicting behavior. Rough estimates from hand calculations should not be utilized when there are better alternatives available.

- **There is a real lack of resources among manufacturers, so provide designers tools to maximize their efforts.** Development resources are limited and overstretched in most companies – an issue that will only get worse as baby

boomers retire. Best-in-Class companies focus their efforts on making their designers more efficient.

➔ **The many benefits of virtual prototyping cannot be overlooked; hand calculations have too many limitations and cannot fully optimize a design.** The metrics support the use of software across the board. Users of virtual prototyping are more likely to hit their product targets, use less prototypes, and decrease overall cost and development time.

Relying solely on hand calculations and physical prototypes is no longer a viable design approach. The benefits of virtual simulation far outweigh those of traditional design methods; software can no longer be overlooked as a tool to maximize product development efforts. Best-in-Class companies have come to rely on this enabler, and as a result, release high quality products on time and at low costs.

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For more information on this or other research topics, please visit www.aberdeen.com.

Related Research

Accelerating Development with Virtual Prototyping; November 2016

Simulation-Integrated Product Development: Achieving More with Less; June 2016

Author: Greg Cline, Research Analyst
Manufacturing, Product Innovation & Engineering

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