

# **Complementary Digital and Physical Prototyping Strategies:**

Avoiding the Product Development Crunch

February 2008

## Executive Summary

As much as some things change, others stay exactly the same. Previous Aberdeen research identified tangible cost and time benefits to eliminating physical prototypes through digital prototyping methods. Findings from this research not only reinforce those findings across the conceptual, detailed design and testing phases of product development, but also show that while most products still require some physical prototypes; leading manufacturers are leveraging them in innovative ways that complement their digital prototyping methods.

### Best-in-Class Performance

Aberdeen used five key performance criteria to distinguish Best-in-Class companies: the ability to meet product revenue targets, cost targets, quality targets, launch dates, and development cost targets. The top 20% of performers across these metrics were aggregated as the Best-in-Class, while the bottom 30% of performers were aggregated as Laggards. The remaining respondents compose the Industry Average.

### Competitive Maturity Assessment

Survey results show that the firms enjoying Best-in-Class performance shared several common characteristics. This includes how they assess form, fit, and function across the product lifecycle, where:

- The Best-in-Class are 2.7-times as likely as Laggards to augment surface modeling with realistic rendering and 3D scanned data with surfaces fitted through them to develop a clearer picture of the design
- The Best-in-Class are twice as likely as Laggard organizations to take advantage of 3D printers and rapid prototyping to create representative parts and products quickly, in addition to using CAD and CAE tools to assess a product virtually
- The Best-in-Class are 1.6-times as likely as Laggard organizations to use digital methods in the testing process to provide guidance on the instrumentation of tests, as well as 1.3-times as likely to digitally review test results to collaboratively find the root cause of product failures

### Required Actions

In addition to the specific recommendations in Chapter Three of this report, to achieve Best-in-Class performance, companies must:

- In the concept phase, assess the product's aesthetics through realistically rendered surface models and close the loop by scanning and surfacing physical concepts
- In the detailed design phase use CAD and CAE applications to digitally assess and 3D Printers to physically assess the product's form, fit and function
- In the testing phase, use CAE applications to determine instrumentation setup and CAT applications to digitally review testing results

#### Research Benchmark

Aberdeen's Research Benchmarks provide an in-depth and comprehensive look into process, procedure, methodologies, and technologies with best practice identification and actionable recommendations

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## Chapter One: Benchmarking the Best-in-Class

### Business Context

Aberdeen research has consistently found a connection between the use of simulation and a reduction in the costs associated with product testing and analysis. But, the driving factor determining how companies leverage simulation has proven repeatedly to be about meeting product development schedules. Seventy percent (70%) of respondents to Aberdeen's October 2006 report, *Simulation-Driven Design: Getting it Right the First Time*, indicated that shortened time to market was the top factor driving them to leverage simulation in design phases of product development. Similarly, 76% of respondents to Aberdeen's September 2007 *Engineering Decision Support: Driving Better Product Decisions and Speed to Market* report indicated that shortening product development schedules was driving how they coordinate, manage, and leverage simulation data.

Respondents to this study did not report anything different (Table I). Shorter product development schedules remain the top factor pushing companies to reevaluate how they assess product behavior, reported by 91% of respondents. Despite the benefits simulation offers for development budgets, this was reported as a factor less than half as often as development schedules.

**Table I: The Top Five Pressures**

Pressures	Response
Shorter product development schedules	91%
Reduced development budgets	38%
Increased product complexity	30%
Accelerated product customization	15%
Increased quality-related costs (warranty, etc.)	11%

Source: Aberdeen Group, February 2008

### The Maturity Class Framework

Between January and February 2008, Aberdeen Group surveyed over 200 manufacturers about their use of simulation and testing throughout product design and development. To determine what practices provide the most tangible business benefits, Aberdeen benchmarked respondents according to five key performance criteria which evaluated their ability to meet crucial product development targets, including:

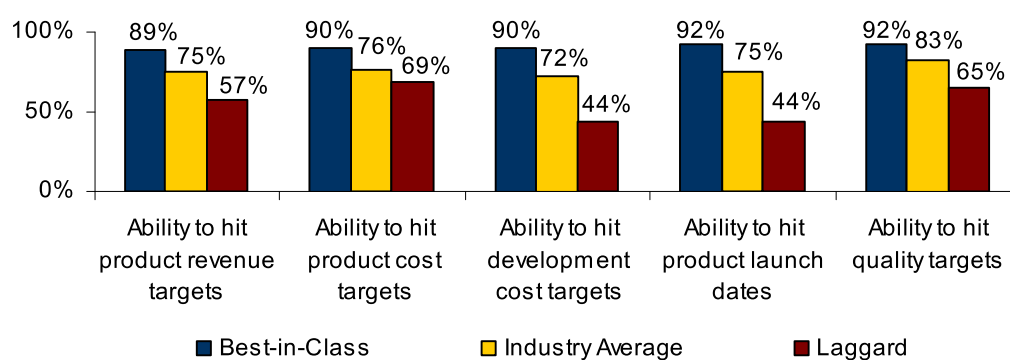
- Product revenue targets
- Product cost targets
- Product launch dates
- Quality targets
- Development cost targets

#### Fast Facts

- ✓ 91% of survey respondents indicated that shorter product development schedules were the top pressure driving how they assess product form, fit, and function
- ✓ The Best-in-Class are able to meet their product launch date targets over twice as often as Laggard organizations

Using these metrics, Aberdeen classified companies into the top 20% (Best-in-Class), the middle 50% (Industry Average) and the bottom 30% (Laggard) of performers. Figure 1 highlights the performance gaps that define each ranking.

**Figure 1: Leading Metrics for Reaching Best-in-Class Status**



Source: Aberdeen Group, February 2008

The two areas that see the largest performance gaps between the Best-in-Class and Laggards are in the ability to meet product launch dates and development cost targets. The Best-in-Class meet each over twice as often as Laggard organizations, speaking directly to the top two pressures driving how companies are seeking to use prototypes. It is significant (given that the overwhelming pressure indicated by survey respondents was shortening product development schedules) that the measure showing the most differentiated performance between the Best-in-Class and the Laggards is the ability to meet product launch dates. What is behind this difference? It's not simply that the Best-in-Class are utilizing digital and rapid prototypes, but how they use them that is important.

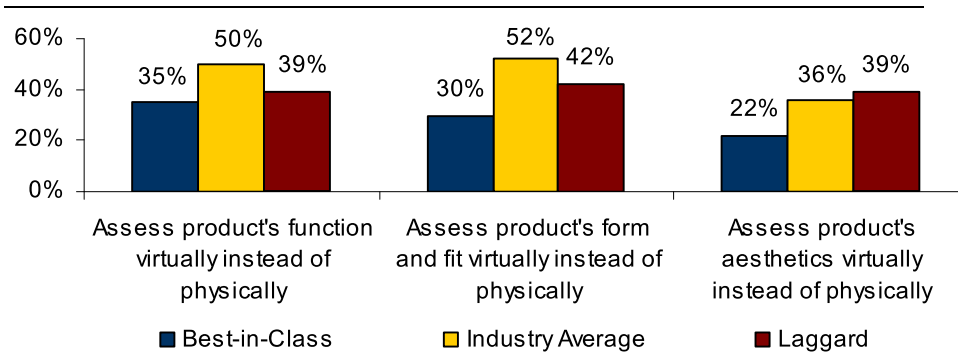
### Best-in-Class Strategies

What do the Best-in-Class do differently? Interestingly, it's not about using simulation to eliminate physical prototypes, it's about how the Best-in-Class are using simulation and adopting new strategies to augment traditional testing processes.

The benefits companies have seen from their use of simulation to assess product form, fit, and function virtually have been significant, reducing physical rounds of testing which can reap considerable savings to product development schedules and budgets. Aberdeen's September 2006 report, [\*Transition from 2D Drafting to 3D Modeling: Improving Engineering Efficiency\*](#), found that the Best-in-Class build on average 1.4 fewer prototypes than the Industry Average as a result of their use of simulation. Similarly, findings from the October 2006 report, [\*Simulation-Driven Design: Getting it Right the First Time\*](#), indicate that the Best-in-Class develop 1.6 fewer prototypes than their competitors.

However, using simulation to replace physical testing does not show as a particularly high priority for the Best-in-Class (Figure 2). Instead, it tends to correlate with Industry Average performance. This doesn't mean that the Best-in-Class aren't using simulation, but that instead of looking at it as a replacement to physical prototypes; they are seeking to use virtual and physical tests as complimentary processes.

**Figure 2: Simulation**



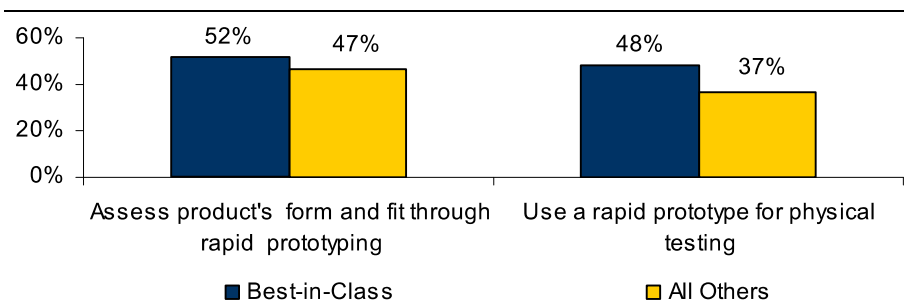
Source: Aberdeen Group, February 2008

"Using simulation means that the first prototype can be very close to a production unit. Physical testing still needs to happen, but many issues can be found in the initial digital mockup and the move to physical prototypes is more tweaking than redesign."

~ Richard Donato  
Mechanical Engineer  
Atlas MTS

To this end, the area where Best-in-Class companies show a higher rate of adoption is in the use of rapid prototyping solutions (Figure 3). And it's not just about using rapid prototypes to assess form and fit, but as a means of physical testing. Rapid prototyping refers to the automated construction of physical models from virtual models through solid freeform fabrication. Parts created using these techniques can be produced in a matter of hours, allowing organizations to assess a product's form and fit cheaply but more importantly without waiting for the construction a full physical prototype.

**Figure 3: Rapid Prototyping**



Source: Aberdeen Group, February 2008

While about half of the Best-in-Class indicate that they are currently using rapid prototyping, they do not show as particularly more likely than their competitors to do so. The adoption of rapid prototypes to assess form and fit is relatively equal for all companies. The Best-in-Class show as more likely to use rapid prototypes for physical testing. This suggests that no one strategy is a determinant of Best-in-Class status, but how they blend both the virtual and physical means of testing throughout the product development lifecycle.



## The Best-in-Class PACE Model

Bringing physical and virtual testing together is the starting point of Best-in-Class performance. Doing so in a way that has a tangible impact on an organization's ability to meet their product development goals requires a combination of strategic actions, organizational capabilities, and enabling technologies that can be summarized as shown in Table 2.

**Table 2: The Best-in-Class PACE Framework**

Pressures	Actions	Capabilities	Enablers
<ul style="list-style-type: none"> <li>Shorter product development schedules</li> </ul>	<ul style="list-style-type: none"> <li>Assess product's form and fit through rapid prototyping</li> <li>Use rapid prototyping for testing</li> <li>Assess product's aesthetics, form, fit, and function virtually instead of physically</li> </ul>	<ul style="list-style-type: none"> <li>Review realistically rendered surface models to assess aesthetics</li> <li>Scan and surface 3D scanned data</li> <li>Assess product form and fit through 3D models</li> <li>Assess product function through simulation</li> <li>Create representative final parts and products quickly</li> <li>Drive test instrumentation from simulations</li> <li>Review testing data in a visual manner</li> <li>Collaborate on digital and physical prototypes</li> </ul>	<ul style="list-style-type: none"> <li>Aesthetic surface modeling</li> <li>3D scanning hardware</li> <li>Computer Aided Design (CAD)</li> <li>Computer Aided Engineering (CAE) / simulation</li> <li>3D printers</li> <li>Computer Aided Testing (CAT)</li> </ul>

Source: Aberdeen Group, February 2008

### Aberdeen Insights — Strategy

Compressed product development schedules have showed as a consistent pressure in recent Aberdeen studies. They appear as the top driver in the changes companies are making to how they leverage 3D design data deliverables outside of engineering, manage engineering change orders, and plan manufacturing processes and develop products that blend mechanical, digital control systems, and electronic design elements. When it comes to how they leverage prototypes and perform tests, however, shorter schedules show as the overwhelming factor, indicated by 91% of all respondents. There's no doubt why stakeholders are trying to reduce prototyping.

Digital prototyping has been available in product development for some time. Its use has shown as a consistent differentiator in past Aberdeen studies, such the March 2007 [Digital Product Development Benchmark Report](#) and the October 2006 [Simulation-Driven Design Benchmark Report](#). This study, however, finds a particular emphasis on the use of rapid prototyping. In some respects, this is a surprising finding as many manufacturers attempt to leverage digital methods in a move away from physical prototypes. However, advances in rapid prototyping and manufacturing technologies have been tremendous. 3D printing technologies now allow the creation of models that come much closer to representing the physical properties of the intended product. This has made rapid physical testing a viable part of product development.

In the next chapter, we will see what the top performers are doing to achieve these gains.

## Chapter Two: Benchmarking Requirements for Success

Virtual prototyping has a lot to offer in itself; but the Best-in-Class have turned it into part of a larger product testing strategy. When it comes to assessing a product's form, fit, and function, they are not only using digital models and simulation assessments; they are using 3D scanning and printing technology to compliment and corroborate the virtual work. What may be most important is that these industry leaders are finding ways to use this combination of virtual and physical tests in ways that specifically address the needs of key phases of product development:

1. Conceptual design
2. Detailed design
3. Testing

Best practices in each of these stages involve capabilities that address business process and organizational adjustment as well as knowledge management components and enabling technology. These characteristics (identified in Table 3, Table 4, and Table 5) correlate directly with Best-in-Class performance across the key metrics.

### Case Study — Ace Pump Corporation

Ace Pump Corporation provides pumping solutions for the chemical application, off-highway equipment, air conditioning, and refrigeration markets. Their product portfolio includes electric motor driven pumps as well as a range of products for the agricultural and off-highway equipment markets that do not require the electrical grid for operation. These varied applications have required Ace to successfully overcome a wide range of engineering challenges.

Ace Pump uses simulation to test the basic functionality of their designs as they develop, but save most evaluation for rounds of physical testing. They set parameters based on past testing data as well as simulations results. This allows them to reach the product performance requirements they've set with a minimum of physical prototypes and test runs.

Much of Ace Pump's physical testing is accomplished through the use of rapid prototyping tools. They utilize laser sintering techniques that use powdered metal composites to fabricate parts directly from 3D CAD data. These models go through a post generation sintering step as well as vacuum impregnation to become machinable as well as water and pressure tight. David Varley, Product Development – Engineering Manager at Ace says, "These prototypes give us a quick turn-around from solid model to finished part, usually within one to two weeks. The advantage of these prototypes is that they can be used for performance testing both at our facility and in the field by potential customers."

*continued*

### Fast Facts

- √ The Best-in-Class are 2.7-times as likely as Laggards to augment surface modeling with realistic rendering and 3D scanned data with surfaces fitted through them to develop a clearer picture of the design
- √ The Best-in-Class are twice as likely as Laggard organizations to take advantage of 3D printers and rapid prototyping to create representative parts and products extremely quickly in addition to using CAD and CAE tools to assess a product virtually
- √ The Best-in-Class are 1.6-times as likely as Laggard organizations to use digital methods in the testing process to provide guidance on the instrumentation of tests, as well as 1.3-times as likely to digitally review test results to collaboratively find the root cause of product failures



### Case Study — Ace Pump Corporation

Additionally, Ace uses pattern makers to produce short run tooling directly from the solid model. This means that prototype parts cast in production material can be machined and handled and tested in the same way as the production parts. "These parts can be produced at much lower cost for multiple samples," says David Varley, "and with a fairly quick turn around, typically two to three weeks at the pattern shop and another week to produce finished casings."

This strategy has caused Ace to see considerable cost and product quality advantages, but the most considerable impact on development schedules. Where developing a prototype and uncovering an issue in the product might have taken several months, they are now able to build and assess a physical prototype within three weeks.

"We send digital models to the customers we are working with to obtain feedback on how the product looks. There tends to be more iterations in the design phase as the customer wants the product to look like a work of art."

~ R. Bradley Michell  
Engineering Manager  
Emco Wheaton

### Conceptual Design - Real Time Design and 3D Scanning

The Best-in-Class' integrated virtual and physical strategy begins in the conceptual design phase. They use digital means to assess a product's aesthetics and scanning technologies to close the process loop for any physical mockups that may be created (Table 3).

**Table 3: The Competitive Framework - Conceptual Design**

	Best-in-Class	Industry Average	Laggard
<b>Process</b>	The product's aesthetic look and feel is assessed by reviewing a realistically rendered digital model		
	<b>71%</b>	<b>63%</b>	<b>62%</b>
	Physical mockups of the product are scanned and digitized		
	<b>42%</b>	<b>28%</b>	<b>11%</b>
	3D models of the product are created by fitting surfaces through 3D scanned data		
<b>Knowledge Management</b>	<b>38%</b>	<b>34%</b>	<b>14%</b>
	Best practices in developing aesthetic digital models and assessing them are captured and reused		
<b>Performance Measurement</b>	<b>47%</b>	<b>31%</b>	<b>19%</b>
	Time from project kickoff to design phase is measured		
<b>Technology</b>	<b>85%</b>	<b>67%</b>	<b>57%</b>
	Technology currently in use:		
	<b>95%</b> software applications that allow for the creation of 3D surface model <b>35%</b> 3D scanners (hardware)	<b>77%</b> software applications that allow for the creation of 3D surface model <b>28%</b> 3D scanners (hardware)	<b>76%</b> software applications that allow for the creation of 3D surface model <b>17%</b> 3D scanners (hardware)

Source: Aberdeen Group, February 2008

### **Real Time Concept Design through Virtual Models**

Specifically, the Best-in-Class start by modeling the aesthetic aspects of the product with high fidelity surface models through a push and pull interaction. This type of interaction is critical, as industrial designers want to organically manipulate the model instead of using an engineering-oriented approach of manipulating model dimensions. Furthermore, they render the models in real time to produce realistic imagery of the product's aesthetics. This combination of push and pull interaction with realistic rendering enables industrial designers to modify the design with realistic renders until it "looks right." While this is done at a slightly higher rate by the Best-in-Class compared to the Industry Average and Laggard organizations, the Best-in-Class also support this practice by identifying, capturing, and then reusing best practices in how they develop and assess these models.

### **Closing the Loop on Concept Physical Prototypes**

In addition to virtually assessing a product's aesthetics, the Best-in-Class are also more likely to close the loop on any physical concept prototypes and bring them into the digital world. They do this by scanning the shape of the physical concept prototype in 3D. The data is then imported into modeling applications where surfaces are fitted through the 3D point cloud of scanned data. Why go through the trouble of getting a physical concept model back into the digital world? There are two distinct reasons:

- A digital representation of product aesthetics is required for coordination and integration with other designers and engineers working on the functional internals of the product.
- Additionally, a digital representation is required for downstream tooling design work. With a digital representation, stamping dies, molds and other tools can't be designed at a high fidelity. Without a high degree of fidelity, costly tooling materials can be wasted in the multiple iterations required to correct them.

As a result, costly tooling materials could be wasted with multiple iterations.

### **Measurement is Important**

Finally, the Best-in-Class are measuring the time it takes to reach the design phase from project kickoff. This is an important performance indicator to track, which speaks to the top pressure of shortening development schedules. The Best-in-Class are tracking their ability to meet these targets even at the earliest stages of the process, which is an early step to understanding how to continue to improve the product development processes.

### **Detailed Design – CAD / CAE and 3D Printing**

With the trend of a complimentary virtual and physical prototyping approach started in the concept design phase, the Best-in-Class continue this trend into the detailed design phase. Specifically, they assess a product's form, fit, and function with Computer Aided Design (CAD), Computer Aided Engineering (CAE), or simulation and 3D printing technologies (Table 4).

"We have used photorealistic models to make paint and color changes. Photographing small equipment can cost seven thousand dollars or more. With a computer model, once the lighting and the colors are set up and the label and textures are set; we can go in, make changes, and then re-render."

~ Richard Donato  
Mechanical Engineer  
Atlas MTS

**Table 4: The Competitive Framework - Detailed Design**

	Best-in-Class	Industry Average	Laggard
<b>Process</b>	3D digital product models		
	<b>100%</b>	<b>87%</b>	<b>78%</b>
	Interferences are identified through checks during static and dynamic product simulations		
	<b>90%</b>	<b>59%</b>	<b>61%</b>
	Product failure modes are checked through simulation		
<b>Organization</b>	<b>65%</b>	<b>60%</b>	<b>41%</b>
	Formal role dedicated to simulation and analysis (employee does not perform any other tasks)		
<b>Knowledge Management</b>	<b>42%</b>	<b>27%</b>	<b>26%</b>
	Simulation methods are adjusted or calibrated based on correlation to testing results		
<b>Technology</b>	<b>75%</b>	<b>41%</b>	<b>42%</b>
	Technology currently in use:		
	<b>77%</b> structural analysis software applications	<b>64%</b> structural analysis software applications	<b>57%</b> structural analysis software applications
	<b>57%</b> fluid / flow analysis software applications	<b>48%</b> fluid / flow analysis software applications	<b>38%</b> fluid / flow analysis software applications

"Running thermal simulations have helped to ensure we are operating below individual component maximum operating specifications before any prototypes have been built or tested."

Source: Aberdeen Group, February 2008

~ Alan Gibson  
Engineering Staff  
Markem-Imaje

### **Form, Fit, and Function Through CAD and CAE**

When it comes to using virtual models for design, the Best-in-Class are taking advantage of new methods of assessing a product's form, fit, and function. These companies are more likely to build 3D models of their products that can then be used to check form and fit. Because the geometry is highly accurate, they can check interferences to head off assembly issues that generate change orders in the testing and manufacturing phases of development.

The Best-in-Class are also more likely to use simulation and analysis applications to assess how a product will perform during tests and in their eventual operating environments. This was a major finding of the October 2006 [The Simulation-Driven Design Benchmark Report](#). This report also found that the Best-in-Class are more likely to perform simulations in earlier stages of the product lifecycle. Doing so allows manufacturers to avoid failure modes during the testing or manufacturing phases that can generate costly change orders. Interestingly, not only are the Best-in-Class more likely to use structural analyses but also fluid flow analyses. Use of these virtual prototyping approaches allows the Best-in-Class to digitally test the broader range of their product's performance.

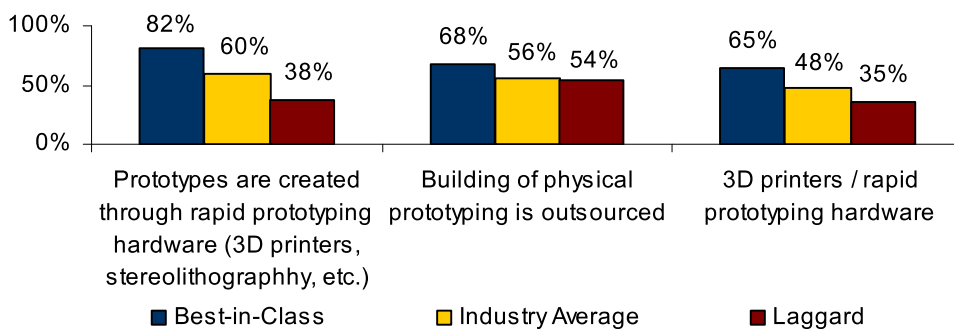
Lastly, the Best-in-Class are more likely to calibrate their simulations based on testing results. Aberdeen's September 2007 [Engineering Decision Support](#):

*Driving Better Product Decisions and Speed to Market* report also found that this is a practice that corresponds to Best-in-Class performance. By tracking both physical and digital test results and how they compare, the Best-in-Class are gaining a deeper understanding of virtual environments. Through iterations on the simulation model and continued correlations, they are beginning to understand what will and what will not work with virtual prototypes. The real benefits, however, are to be realized in later projects, as these companies develop more accurate simulations in a convergence test and simulation. Doing so requires a deep commitment to growing and managing this body of knowledge.

### **3D Printing Accelerates Mainstream Rapid Prototyping**

To compliment the virtual prototyping approaches used in the detailed design phase, the use of 3D printers have made dramatic strides in adoption (Figure 4).

**Figure 4: Physical Prototyping**



Source: Aberdeen Group February, 2008

Rapid prototyping technologies have become easier to maintain and use, expanding from their roots into what is known as 3D printing. Dramatic advances in 3D printing technologies now allow for parts and products that increasingly represent the manufactured end item in several ways:

- 3D printers can now build parts and products out of a wide variety of materials that will accurately represent functional final parts. This allows manufacturers to not only use these parts for a form and fit assessment, but also from a functional perspective. Furthermore, some of the parts from these 3D printers can even be used as production parts.
- 3D printers also have made tremendous strides in terms of including multiple materials and surface finishes on the products or product parts. Again, parts produced by 3D printing increasingly represent final parts even as they get more complex.
- 3D printers now have the capability to use multiple colors within a single part or product. From an aesthetic perspective, these parts again are becoming more representative of final parts.

"We attempt to get rapid prototypes that are made in materials similar to the materials we will use in the final product. This way we can perform functional tests to determine if the product will behave as expected. We also use them for fit so we can determine if we are designing a product that uses the least number of parts and can be assembled easily. The models are faster to produce and in most cases less expensive than traditional cast models."

~ R. Bradley Michell  
Engineering Manager  
Emco Wheaton

## Testing - CAT and Simulation Based Instrumentation

The testing phase of product development is where the rubber must meet the road. The product coming out of this phase must meet the original requirements set out for it in the planning phase. And while much of what happens in the testing phase happens in the physical world, the Best-in-Class are leveraging digital solutions (Table 5).

**Table 5: The Competitive Framework - Testing**

	Best-in-Class	Industry Average	Laggard
<b>Process</b>	Simulation results are used to determine testing instrumentation setup		
	<b>62%</b>	<b>38%</b>	<b>39%</b>
	Testing data is acquired and saved		
	<b>87%</b>	<b>86%</b>	<b>83%</b>
	Product performance is assessed during test by visually reviewing test results		
	<b>90%</b>	<b>85%</b>	<b>83%</b>
	Root cause analysis is performed after testing failure		
	<b>78%</b>	<b>65%</b>	<b>58%</b>
<b>Organization</b>	Formal collaboration processes to review and collect feedback on (physical / digital) prototypes		
	<b>71%</b>	<b>44%</b>	<b>51%</b>
	Formal role dedicated to physical testing (employee does not perform any other tasks)		
<b>Performance Measurement</b>	<b>52%</b>	<b>33%</b>	<b>25%</b>
	Amount of time required to plan testing phase is measured		
<b>Technology</b>	<b>59%</b>	<b>30%</b>	<b>33%</b>
	Technology currently in use:		
	<b>73%</b> data acquisition hardware <b>50%</b> CAT software applications	<b>64%</b> data acquisition hardware <b>42%</b> CAT software applications	<b>50%</b> data acquisition hardware <b>19%</b> CAT software applications

"Simulation provides a graphical method for calculations. Very few requirements can be met by calculation unless it is backed up by physical test. However, prior knowledge of similar products helps in eliminating 'dead ends' during physical performance tests."

-Engineering Manager  
Manufacturer,  
Aerospace and Defense

Source: Aberdeen Group, February 2008

Specifically, the Best-in-Class follow a sequence of events in testing. As a first step, they don't simply look at initial requirements and determine the instrumentation of the test. They first review the results of the simulation of the product's performance to gain an idea of where to place sensors. In the end this results in better overall instrumentation of the test which, in turn, will result in better data acquired during the test.

Acquisition of test data is reported relatively evenly across the competitive framework. However, this often results in a dramatically larger data set that

can be difficult to manage. While acquiring this data isn't differentiated, what companies are doing with the acquired data is. The Best-in-Class are more likely to visually review it with CAT technology. These applications visually display the results of the testing data, often mapped onto a 3D model, in a similar manner as results from a simulation or analysis fringe plot. For example, red areas highlight regions of high stress, and blue areas highlight areas of low stress. This is beneficial because the testing data becomes dramatically easier to interrogate and understand. Visual reviews of test data can also reveal secondary failure modes of products. When multiple failure modes are identified in a single test, more problems can be addressed in less time, without running another test to find additional failure modes.

Often, when a test fails, understanding why the product failed can present a serious challenge. The Best-in-Class are more likely to not only perform a root cause analysis that procedurally hones in on the initial cause of the issue, but they are also more likely to collaborate with those outside the test lab.

### Aberdeen Insights — Technology

Throughout the product development process, Best-in-Class performers are taking advantage of a twin approach, incorporating both digital and physical testing methods. More importantly, the way that these two methods converge changes according to the needs of different stages of development:

- **Conceptual design.** The Best-in-Class are augmenting surface modeling with realistic rendering with 3D scanned data and surfaces fitted through them to develop a clearer picture of the design before the real design work begins.
- **Detailed design.** The Best-in-Class take advantage of CAD and CAE tools to virtually assess a product's form fit and function while also turning to 3D printers to create representative parts and products extremely quickly.
- **Testing.** The Best-in-Class enhance the testing process with digital methods, providing guidance on instrumentation with simulation as well as digitally reviewing test results to collaboratively find the root cause of product failures.

Whether a product's concept or industrial design aesthetics is created by starting with digital models or with physical concept models and then turned into a digital model, the handoff into the detailed design phase is made more easily with digital deliverables. The advantage is that both design intent and intellectual property are captured within the digital model and transferred to the stakeholders downstream. As a result, product knowledge is not lost during the transition, which allows those in the detailed design phase to get a head start. This helps to save time under shrinking product development schedules.



## Chapter Three: Required Actions

Digital prototypes can provide substantial benefits in the reduction of physical prototypes. The Best-in-Class, however, are seeing even greater advantages as a result of how they combine the two across all stages of product development. Whether a company is trying to move its performance from Laggard to Industry Average, or Industry Average to Best-in-Class, the following actions will help spur the necessary performance improvements: While these recommendations to be taken in all stages of development, they are not necessarily sequential.

### Laggard Steps to Success

- **Adopt 3D modeling through Computer Aided Design (CAD).** An effective use of simulation begins in 3D design. 3D models can be used to assess form and fit. One hundred percent (100%) of the Best-in-Class indicate the use of 3D modeling.
- **Use Computer Aided Engineering (CAE) to simulate and identify product failure modes.** The Best-in-Class are 1.6-times as likely as Laggards to leverage simulation to check product failure modes. This allows for an ability to recognize issues earlier, when they can be resolved more easily, avoiding costly and time consuming change orders downstream.
- **Use 3D printing to create representative physical parts and products.** Simulation alone isn't enough and traditional physical tests can involve considerable amounts of work to build. Rapid prototyping offers an alternative, allowing companies to assess the form and fit of parts without having to construct a complete prototype. The Best-in-Class are twice as likely as Laggards to take advantage of this technology.
- **Scan and surface concept prototypes.** The Best-in-Class are 3.8-times as likely as Laggards to scan physical mockups of a product that can then be surfaced using scanned data. These can be used to create a digital record of the design that can be used downstream.
- **Visually review testing results with Computer Aided Testing (CAT) applications.** While visual review makes testing results easier to understand, viewing results mapped onto a 3D model can make it easier to identify additional failure modes without resulting in unnecessary rounds of testing. The Best-in-Class are 2.6-times as likely as Laggards to use these tools.

### Industry Average Steps to Success

- **Interference detection in 3D models.** While 87% of the Industry Average create 3D product models, only a little over half of these companies are using these models to check for interferences. Ninety percent (90%) of the Best-in-Class do so,

#### Fast Facts

- ✓ In the concept phase, assess the product's aesthetics through realistically rendered surface models and close the loop by scanning and surfacing physical concepts
- ✓ In the detailed design phase use CAD and CAE applications to digitally assess, and 3D printers to physically assess the product's form, fit, and function
- ✓ In the testing phase, use CAE applications to determine instrumentation setup and CAT applications to digitally review testing results

"Digital models are great for working with marketing, industrial designers and other engineers to ensure we have general 'buy-in' on product design and 'look' before having to manufacture any prototype parts or assemblies, which reduces development time and cost."

~ Alan Gibson  
Engineering Staff  
Markem-Imaje

which allows them to resolve assembly issues far in advance of testing and manufacturing.

- **Create aesthetic surface models and assess with realistic renderings.** The Best-in-Class are more likely to create surfaces directly and that render it until they have a realistic representation of the product that can be used to assess product aesthetics.
- **Calibrate simulations based on testing results.** The Best-in-Class are 1.8-times as likely as the Industry Average to compare and alter simulations based on physical test results. Doing so yields more accurate simulations and ultimately can result in less rounds of physical testing.
- **Use simulations to determine testing instrumentations.** The Best-in-Class aren't simply calibrating simulations; they are using what they learned from virtual tests to determine where to place sensors and plan the overall instrumentation of physical tests. They are 1.6-times as likely as the Industry Average to do so.

### Best-in-Class Steps to Success

- **Measure time from project kickoff to design phase.** A large segment of the Best-in-Class are measuring the time from project kickoff to the beginning of the design phase. Those who are not need to do so. As development cycles continue to shrink, recognizing the time required for design activities can lead to identifying how to continue to improve.
- **Measure time to testing planning completion.** Fewer Best-in-Class performers indicated that they measure the time required for plan testing than for conceptual design activities. The value here is the same: understanding how long processes take leads to an understanding of where companies can focus their efforts to speed processes.

"Between the building of the first prototype and before initial production, the unit is reviewed for serviceability for ease of assembly. We even modeled hand tools and calibration devices to check the ergonomics of the model. Every suggestion is noted and before first production, a review of all the suggestions as well as the fixes is mandated between engineering, service, and assembly."

~ Richard Donato  
Mechanical Engineer  
Atlas MTS

#### Aberdeen Insights — Summary

The Best-in-Class are leveraging digital and rapid prototyping technologies in a way that's driving more efficient product development, but the value of digital product definitions extends beyond the testing phase and into the release to manufacturing. Digital models are more portable and, as they can be passed between organizations easily, provide a medium for collaboration.

Digital product definitions mean that manufacturing operations can be planned more accurately, as the product definition is preserved and has much less ambiguity. An additional benefit of this is that the product can be assessed for manufacturability earlier in product development. This allows engineering organizations to address problems that may not be issues in the design itself, but in its production while the design is still fluid. Both of these uses save on overall time to market, allowing manufacturing processes to be developed earlier, and allowing manufacturers to ensure that these processes are being planned effectively.

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## Appendix A: Research Methodology

Between December and February 2008, Aberdeen examined the experiences and intentions of more than 260 enterprises regarding their use of virtual and physical prototyping technologies, processes, and strategies. Aberdeen supplemented this online survey effort with interviews with select survey respondents.

Responding enterprises included the following:

- *Job title / function:* The research sample included respondents with the following job titles: engineering staff (35%); engineering management (24%); senior management (13%); and director (6%).
- *Industry:* The research sample included respondents from across a number of discrete and process manufacturing industries. The largest groups of respondents came from the following sectors: industrial equipment manufacturing (35%); aerospace and defense (26%); and automotive (26%).
- *Geography:* The majority of respondents (77%) were from North America. Remaining respondents were from Europe (13%); the Asia-Pacific region (7%); South or Central America (2%); and the Middle East or Africa (1%).
- *Company size:* Twenty percent (20%) of respondents were from large enterprises (annual revenues above US \$1 billion); 31% were from midsize enterprises (annual revenues between \$50 million and \$1 billion); and 49% of respondents were from small businesses (annual revenues of \$50 million or less).
- *Headcount:* Forty-two percent (42%) of respondents were from small enterprises (headcount between 1 and 99 employees); 24% were from midsize enterprises (headcount between 100 and 999 employees); and 34% of respondents were from small businesses (headcount greater than 1,000 employees).

Solution providers recognized as sponsors were solicited after the fact and had no substantive influence on the direction of this report. Their sponsorship has made it possible for Aberdeen Group to make these findings available to readers at no charge.

### Study Focus

Responding engineering executives completed an online survey that included questions designed to determine the following:

- √ The degree to which digital and rapid prototyping methods are deployed in their product development operations
- √ The structure and effectiveness of existing prototyping and simulation processes
- √ Current and planned use of technology including design tools, simulation applications, and outsourced services to aid product development activities
- √ The benefits, if any, that have been derived from the use of these technologies

The study aimed to identify emerging best practices for the use of simulation and physical testing usage, and to provide a framework by which readers could assess their own capabilities

**Table 6: The PACE Framework Key**

Overview
<p>Aberdeen applies a methodology to benchmark research that evaluates the business pressures, actions, capabilities, and enablers (PACE) that indicate corporate behavior in specific business processes. These terms are defined as follows:</p> <p><b>Pressures</b> — external forces that impact an organization’s market position, competitiveness, or business operations (e.g., economic, political and regulatory, technology, changing customer preferences, competitive)</p> <p><b>Actions</b> — the strategic approaches that an organization takes in response to industry pressures (e.g., align the corporate business model to leverage industry opportunities, such as product / service strategy, target markets, financial strategy, go-to-market, and sales strategy)</p> <p><b>Capabilities</b> — the business process competencies required to execute corporate strategy (e.g., skilled people, brand, market positioning, viable products / services, ecosystem partners, financing)</p> <p><b>Enablers</b> — the key functionality of technology solutions required to support the organization’s enabling business practices (e.g., development platform, applications, network connectivity, user interface, training and support, partner interfaces, data cleansing, and management)</p>

Source: Aberdeen Group, February 2008

**Table 7: The Competitive Framework Key**

Overview
<p>The Aberdeen Competitive Framework defines enterprises as falling into one of the following three levels of practices and performance:</p> <p><b>Best-in-Class (20%)</b> — Practices that are the best currently being employed and are significantly superior to the Industry Average, and result in the top industry performance.</p> <p><b>Industry Average (50%)</b> — Practices that represent the average or norm, and result in average industry performance.</p> <p><b>Laggards (30%)</b> — Practices that are significantly behind the average of the industry, and result in below average performance.</p>
<p>In the following categories:</p> <p><b>Process</b> — What is the scope of process standardization? What is the efficiency and effectiveness of this process?</p> <p><b>Organization</b> — How is your company currently organized to manage and optimize this particular process?</p> <p><b>Knowledge</b> — What visibility do you have into key data and intelligence required to manage this process?</p> <p><b>Technology</b> — What level of automation have you used to support this process? How is this automation integrated and aligned?</p> <p><b>Performance</b> — What do you measure? How frequently? What’s your actual performance?</p>

Source: Aberdeen Group, February 2008

**Table 8: The Relationship Between PACE and the Competitive Framework**

PACE and the Competitive Framework – How They Interact
<p>Aberdeen research indicates that companies that identify the most impactful pressures and take the most transformational and effective actions are most likely to achieve superior performance. The level of competitive performance that a company achieves is strongly determined by the PACE choices that they make and how well they execute those decisions.</p>

Source: Aberdeen Group, February 2008

## **Appendix B: Related Aberdeen Research**

Related Aberdeen research that forms a companion or reference to this report include:

- *Engineering Decision Support: Driving Better Product Decisions and Speed to Market* September 2007
- *The Simulation-Driven Design Benchmark Report: Getting It Right the First Time* October 2006
- *The Transition from 2D Drafting to 3D Modeling Benchmark Report: Improving Engineering Efficiency* September 2006

Information on these and any other Aberdeen publications can be found at [www.Aberdeen.com](http://www.Aberdeen.com).

**Author: Chad Jackson, Research & Service Director**  
[chad.jackson@aberdeen.com](mailto:chad.jackson@aberdeen.com)

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