

Getting Product Design Right the First Time with CFD

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Michelle Boucher, Colin Kelly-Rand

Executive Summary

As companies position themselves for the economic recovery, they are once again looking to bring new products to market quickly, yet keep costs down, while also ensuring high quality. A "get it right the first time" product development strategy is key to achieving this. This report provides guidance to help companies that develop products that are impacted by fluid or gas flow, heating or cooling, chemical reactions, turbulence, and other related physical phenomena to make better designs that will ultimately lead to more profitable products.

Best-in-Class Performance

Aberdeen used the following five key performance criteria to distinguish Best-in-Class companies with top performers achieving the following results:

- 89% of products met release dates
- 28% decrease in development time since implementing the current approach for assessing product behavior
- 90% of products met quality targets
- 87% of products met cost targets
- 24% reduction in product cost since implementing the current approach for assessing product behavior

Competitive Maturity Assessment

When compared to competitors, firms enjoying Best-in-Class performance shared several common characteristics that enable them to make better design decisions:

- 44% more likely to use Computational Fluid Dynamics (CFD) results to promote collaboration between analysts and engineers
- 32% more likely to evaluate what-if scenarios / Design of Experiments (DOE) using CFD analyses
- 32% more likely to track shortcomings of simulations to apply to improving future models

Required Actions

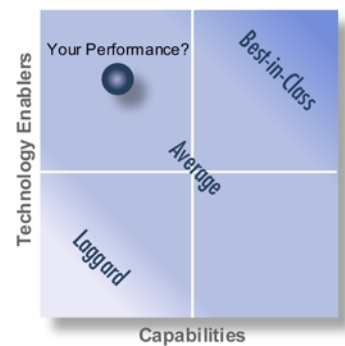
In addition to the specific recommendations in Chapter Three of this report, to achieve Best-in-Class performance, companies must:

- Capture and document best practices for conducting simulations and make them centrally available
- Centrally manage previous simulation results
- Vary input variables in simulations with probabilities

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

How Does Your Performance Compare to the Best-in-Class?



- Compare your processes
- Receive a free, personal PDF scorecard
- Benefit from custom recommendations to improve your performance, based on the research

Take the Assessment

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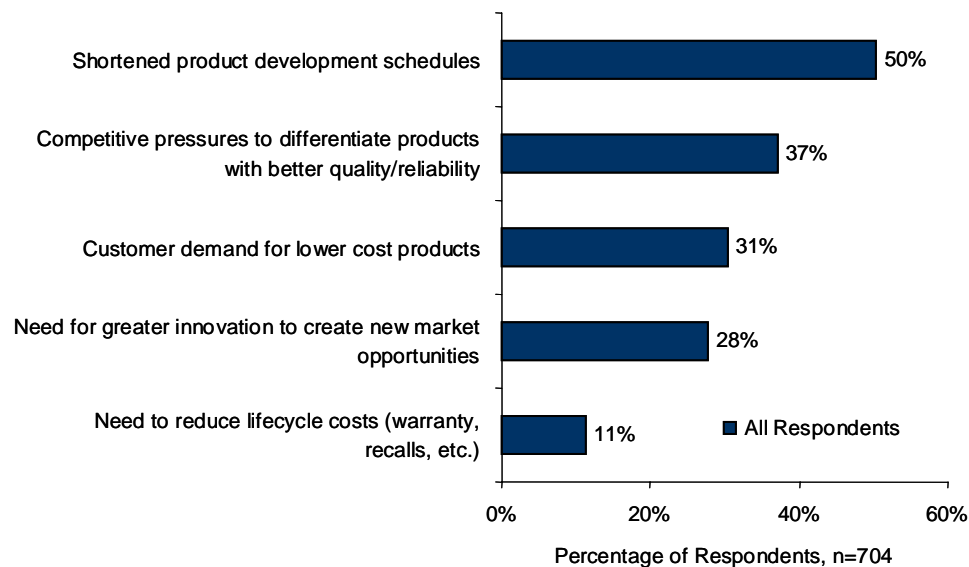
Chapter One: Benchmarking the Best-in-Class

Research from Aberdeen's November 2008 *Engineering Evolved* report, found that those leveraging three or more different types of simulations are able to reduce the number of physical prototypes by 37%. This leads to cost reductions of up to \$332,673 and 118 days from the development process for complex products. Computational Fluid Dynamics (CFD) is an example of one type of simulation. Does its use contribute to this type of value? Does it help to more realistically predict product behavior to enable better decisions? Does it have an impact on product quality or does it just slow down the development process? To answer these questions, Aberdeen studied the experiences of 704 companies in March and April 2011 through a survey and interviews. These 704 companies were selected based on the profile of the products developed by these companies and confirming that their products are impacted by the conditions assessed by CFD (see Definition of CDF in the sidebar).

The Business Needs to Obtain Better Insight into Product Behavior

To understand the external factors driving companies to better understand product behavior during the development process, survey respondents were asked to pick the top two external pressures impacting them the most. The top pressures are time and quality, followed by cost (Figure 1).

Figure 1: Top Business Pressures Driving a Better Understanding of Product Behavior



Source: Aberdeen Group, April 2011

Fast Facts

Since implementing their current process to assess product behavior, Best-in-Class companies have been able to:

- ✓ Reduce development time by **28%**
- ✓ Lower product cost by **24%**
- ✓ Produce **23%** fewer physical prototypes

Definition of CFD

Computational Fluid Dynamics (CFD) is a specialized simulation that analyzes fluid flow. It can be used to assess both liquid and gas flows as well as their interactions. Depending on the application, CFD can be used to obtain better insight into:

- Air / Gas flow
- Fluid flow
- Heating / Cooling
- Chemical reactions / combustion
- Turbulence
- Other related physical phenomena

Interestingly, time to market pressures driving shortened development schedules is the top pressure on product development. What is extremely interesting about this is that findings from just last year (April 2010 [Cost Saving Strategies for Engineering: Using Simulation to Make Better Decisions](#) report) found that cost was the driving pressure while time was number two. This shift demonstrates that time is always an important pressure, but cost becomes even more important in a down economy.

Obtaining better insight into product behavior does consume more time early in the development cycle so it may seem like a counterintuitive step to take when trying to shorten design times. However, investing this time up front pays off in the end. With a greater understanding of how the final product will function, engineers can make more accurate design decisions throughout the development process. Not only does this lead to better designs, but problems are caught and addressed early on when they are easier to address. Problems found later are much more difficult to address and are likely to end up costing more and causing delays.

A further shift in pressures compared to last year, quality has moved from number three to number two. This provides even further evidence that business is looking better as customers can now afford to pay a little more for better quality and as a result, quality has become more important than cost. This makes sense as high quality is a more sustainable way to differentiate products, especially if the last couple of years have forced prices to drop as low as they can. With better insight into product behavior, engineers can make the right decisions to improve product quality, while still keeping costs down. This simultaneously addresses pressures to differentiate products with high quality while addressing customer demands for lower prices.

What Challenges Must Be Addressed to Obtain Better Insight into Product Behavior?

As indicated by the pressures, product development needs better insight into product behavior to address time, quality, and cost pressures. Addressing these pressures is critical as they ultimately impact product profitability. To understand what challenges must be addressed in order to obtain better insight into product behavior, survey respondents were asked to pick their top two challenges of understanding product behavior. The challenges boil down to one thing: complexity.

Top on the list of challenges is that the products themselves are becoming increasingly complex. Many products have evolved into complex systems of mechanical components, electronics, and software, involving multiple engineering disciplines. In addition, the increasing number of components, often combined with miniaturization, requires an even greater understanding of how these components will interact, while making sure they do not overheat. Then, to add yet another level of complexity, products are often offered in multiple configurations, where the performance of each must be understood.

"We needed to optimize of the internal fluid-dynamic of an oven. Coupling CAD, CFD code and an optimization code we automatically tested more than 100 hundred different solutions in few weeks. The physical tests have been reduced to 3 major designs."

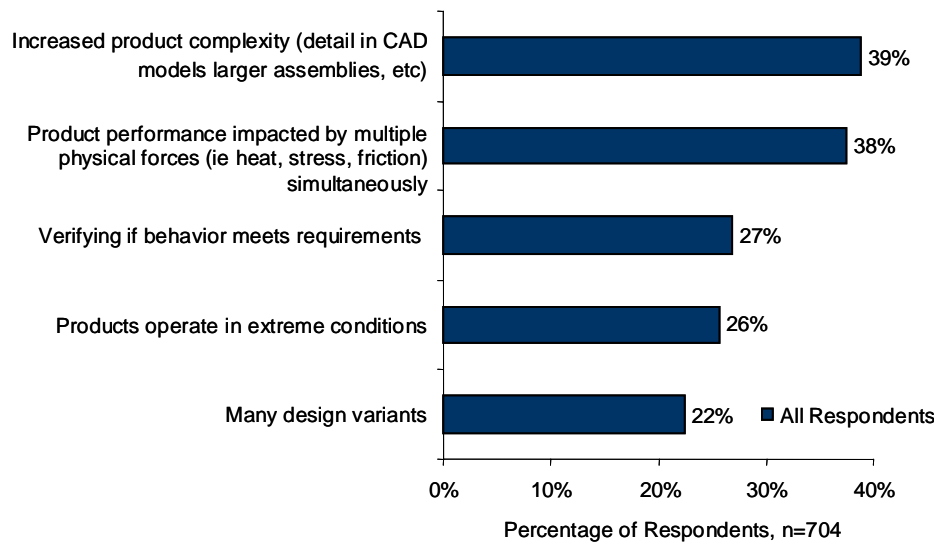
~ Manager, Consumer
Products

In the real world, there are a variety of simultaneous physical forces and phenomena that impact product behavior. These forces, coupled with the complexity on the products, makes predicting how the product will function in a real world environment extremely difficult. This creates a need for improved ways for assessing product behavior against a variety of multiple physics. Related to this, some products operate in extreme environments such as very high or low temperatures. This further complicates understanding all the difficult physical forces on the product.

Finally, with complex products operating in a complex environment, it becomes extremely difficult to verify if the product will actually do what it is suppose to, given all the variables that impact performance. Even with physical testing, it is virtually impossible to assess every condition that impacts a product's performance to confirm it meets design requirements.

Addressing these challenges will allow companies to improve the overall product integrity. Improving product integrity creates greater customer satisfaction which in turn creates greater demand for the company's products. Consequently, these steps lead to greater product profitability.

Figure 2: Top Challenges of Understanding Product Behavior



Source: Aberdeen Group, April 2011

"As a service organization, we focus on the reduction in development time and cost for our customers. Recently, we needed to increase the efficiency of certain compressors and CFD simulation was key to addressing this problem. It helped us identify and validate improvements in the overall efficiency. In addition, the CFD predicted results matched tests carried out by our customers."

~ Dr. T. C. Ramesh, General Manager, Quality Engineering and Software Technologies (QuEST)

The Maturity Class Framework

To understand successful approaches for understanding product behavior during development, as well as the business impact it has, Aberdeen benchmarked the performance of study participants and categorized them as either Best-in-Class (top 20% of performers), Industry Average (mid 50%), or Laggard (bottom 30%). The top pressures driving better insight into product behavior are time, quality, and cost. Indications of successful approaches to addressing the challenges of obtaining better insight into product behavior will be those companies whose efforts enable them to

achieve the desired business results that address those top pressures. Consequently, five key performance measures that indicate success with addressing the pressures were used to distinguish the Best-in-Class from Industry Average and Laggard organizations. The performance of each of these tiers is displayed in Table I. These metrics show success with releasing products on time, reducing development time, meeting both cost and quality targets, while still lowering product cost.

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

Definition of Maturity Class	Mean Class Performance
<p>Best-in-Class: Top 20% of aggregate performance scorers</p>	<ul style="list-style-type: none"> ▪ 89% of products met release dates ▪ 28% decrease in development time since implementing current approach for assessing product behavior ▪ 90% of products met quality targets ▪ 87% of products met cost targets ▪ 24% reduction in product cost since implementing current approach for assessing product behavior
<p>Industry Average: Middle 50% of aggregate performance scorers</p>	<ul style="list-style-type: none"> ▪ 74% of products met release dates ▪ 14% decrease in development time since implementing current approach for assessing product behavior ▪ 82% of products met quality targets ▪ 74% of products met cost targets ▪ 10% reduction in product cost since implementing current approach for assessing product behavior
<p>Laggard: Bottom 30% of aggregate performance scorers</p>	<ul style="list-style-type: none"> ▪ 52% of products met release dates ▪ 2% decrease in development time since implementing current approach for assessing product behavior ▪ 70% of products met quality targets ▪ 50% of products met cost targets ▪ 2% reduction in product cost since implementing current approach for assessing product behavior

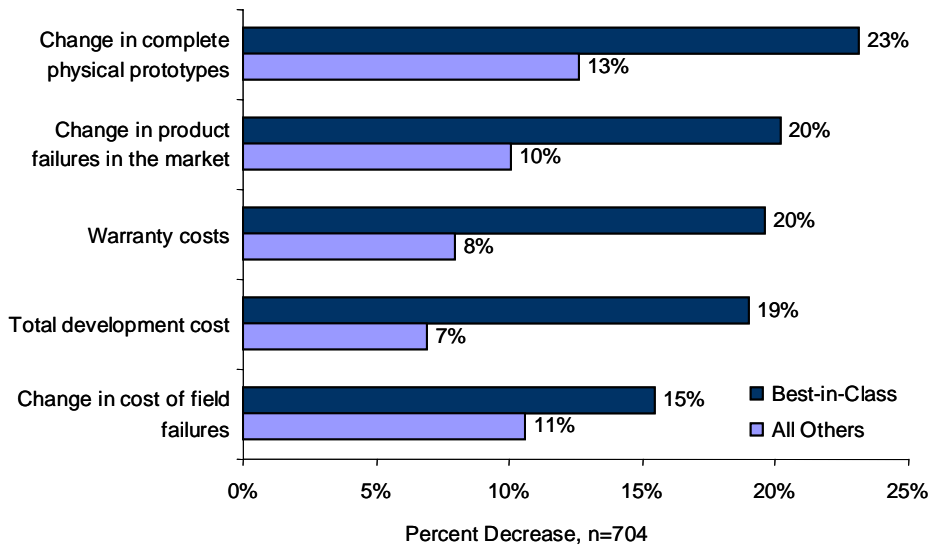
Source: Aberdeen Group, April 2011

The Best-in-Class successfully address the top pressure of shortened development schedules and as a result are 19% more likely than the Industry Average to release their products on time. They have also reduced their development time by an impressive 28% since implementing their current process for assessing product behavior. Their approaches have allowed them to obtain insight into product behavior so they can make better decisions to avoid finding problems, such as overheating, later on when they cause delays in product release as a solution is investigated. The work they do up front provides them with a deeper understanding of the product and

key factors that impact performance criteria, enabling time savings later on in the development process.

This deeper understanding of product behavior also provides engineers at Best-in-Class companies the needed guidance to better evaluate design alternatives which leads to higher quality design. However, even more impressive, they are able to achieve this higher quality design without driving up costs. They are 18% more likely than the Industry Average to meet cost targets and have actually taken 2.4 times more cost out of their products since implementing their current approaches for assessing product behavior. Given the complexity of products and the environments they operate in, the Best-in-Class have clearly taken the right steps to competitively differentiate their products with high quality, without adding cost and still release products on time. These steps provide the Best-in-Class with other benefits as well (Figure 3).

Figure 3: Additional Benefits Since Implementing Current Approach for Assessing Product Behavior



"Using CFD as an optimization tool, we were able to reduce unsteady forces on key components - thereby reducing structural loading requirements and ultimate cost of the product."

~ Thomas Clark, CTO, Green-Tide Turbines Ltd

Source: Aberdeen Group, April 2011

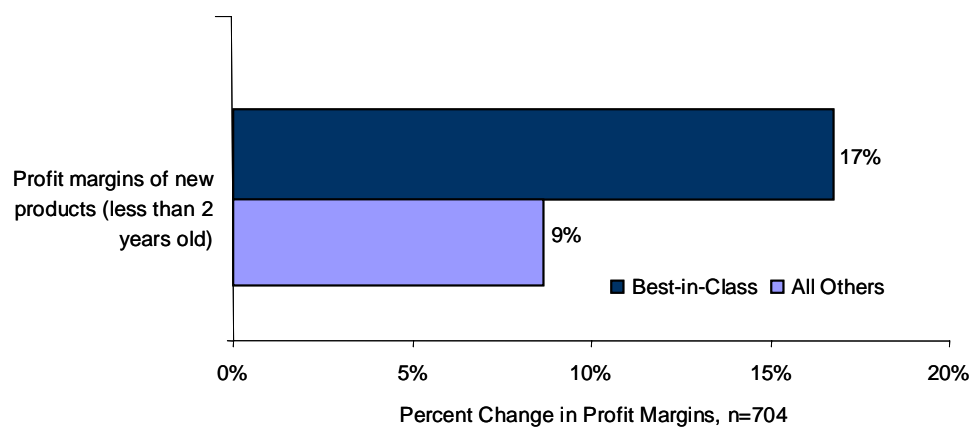
With shorter development time, it also costs less to development products and the Best-in-Class have enjoyed an associated 19% reduction in development costs. This also shows they are taking the right steps to utilize the expertise of their most experienced and knowledge staff.

The work the Best-in-Class do to better understand product behavior ends up saving both time and cost with a reduction in physical prototypes. Since implementing their current process to assess product behavior, they have reduced the number of physical prototypes they produce 83% more than their competitors. This is particularly impressive given the increasing product complexity and number of variables impacting performance in the real world. As seen by the Best-in-Class's ability to meet quality targets, this reduction in physical prototypes has not hurt quality.

Not only does the ability to meet quality targets provide valuable brand differentiation, but it also saves costs later on. They have been able to reduce the number of field failures by 20% which results in a 15% reduction in the cost of field failures and a 20% reduction in warranty costs.

Ultimately, these benefits result in greater product profitability (Figure 4). Clearly, enabling product development teams to make better design decisions has a direct impact on the success of the overall company.

Figure 4: Best-in-Class Enjoy a Higher Percent Increase in Profit Margins for New Products



Source: Aberdeen Group, April 2011

The Best-in-Class PACE Model

The ability to differentiate products with high quality while still keeping costs down and releasing products on time requires a combination of strategic actions, organizational capabilities, and enabling technologies that are summarized in Table 2.

Table 2: The Best-in-Class PACE Framework

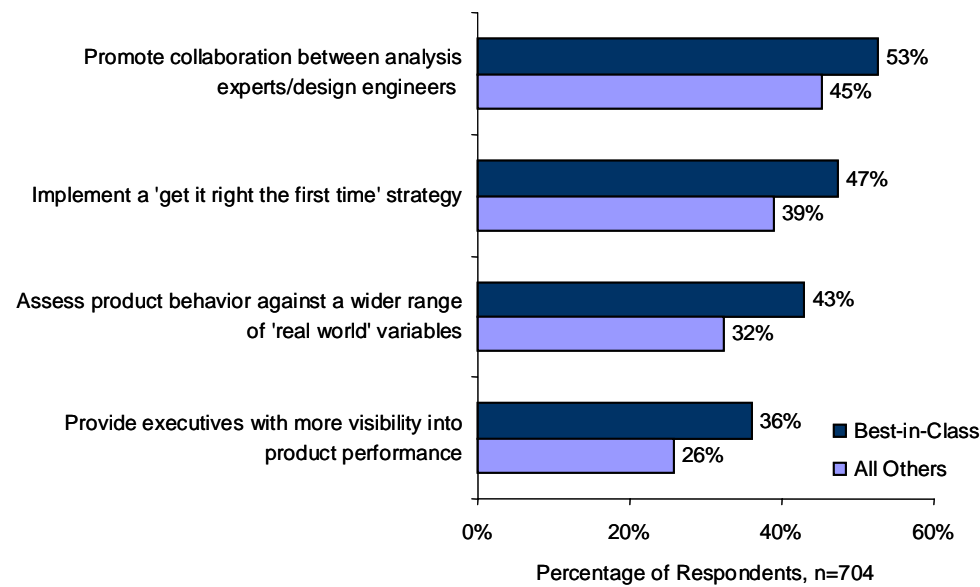
Pressures	Actions	Capabilities	Enablers
<ul style="list-style-type: none"> ▪ Shortened product development schedules 	<ul style="list-style-type: none"> ▪ Promote collaboration between analysis experts/design engineers ▪ Implement a 'get it right the first time' strategy ▪ Assess product behavior against a wider range of 'real world' variables 	<ul style="list-style-type: none"> ▪ Simulation is used to make trade-off decisions ▪ Engineers assess multiple engineering criteria simultaneously ▪ CFD results used to collaborate with design engineers, R&D engineers, and analysts ▪ Design engineers have access to CFD results 	<ul style="list-style-type: none"> ▪ CFD Analysis ▪ Input parameters varied based on probabilities ▪ Structural analysis

Source: Aberdeen Group, April 2011

Best-in-Class Strategies

Given the performance benefits enjoyed by the Best-in-Class, they are clearly doing a better job of addressing the challenges of assessing product behavior to make better design decisions that ultimately leads to more profitable products. The top strategies implemented by the Best-in-Class are shown in Figure 5. The approach Best-in-Class companies are taking is to provide better visibility and understanding during development.

Figure 5: Top Strategies to Improve How Product Behavior Is Assessed



Source: Aberdeen Group, April 2011

"We used simulation to determine causes for observed failures as well as to try out and optimize improvements to product design."

~ Viet Hoang, Development Engineer (E.I.T.), Alberta Centre for Advanced MNT

The top strategy to improve how product behavior is assessed is to support greater collaboration between analysts and design engineers. Through greater collaboration, analysts can provide more input early on during the design process when their expertise has the greatest impact. In addition, collaboration provides design engineers with support and guidance to develop their own expertise so that they can conduct their own analyses to guide decision making. With this approach, analysts can focus on the problems involving a high level of expertise while the more basic simulations that provide directional guidance can be handled by the design engineers.

This collaboration supports getting it right the first time as a strategy. By taking the time to make the educated design decisions up front, the design is right from the beginning. This more efficient and than having one design and iterating it multiple times to address problems identified in final testing and ultimately leads to shorter development time.

The complexity of products as well as the environment they operate in requires assessing against a wider range of real world variables. The Best-in-Class are 33% more likely than their competitors to do this, making it one

of the most differentiated strategies and a key contributor to their success. This strategy supports getting it right the first time as there is a better understanding of how a variety of variables will impact performance. The performance of products developed by the respondents for this study are impacted by the flow of fluids or gases, heating and cooling, chemical reactions, and turbulence. The Best-in-Class are more likely to ensure they have insight into how these conditions impact the performance of their products.

Finally, the Best-in-Class are 39% more likely to provide management visibility to product performance, giving them early insight into the products the company will be releasing to the market. Given how design decisions affect how quickly products get to market, impact brand reputation, and contribute to the company bottom line, this visibility provides management with critical information about the future profitability of the products they are bringing to market. This supports better forecasting, but even more importantly they can make adjustments as needed to optimize profitability. Given that this has become a top strategy for Best-in-Class organizations, they are recognizing that engineering should not be a "black box." Engineering makes many decisions that directly impact company profitability that management should have visibility into.

Aberdeen Insights — Strategy

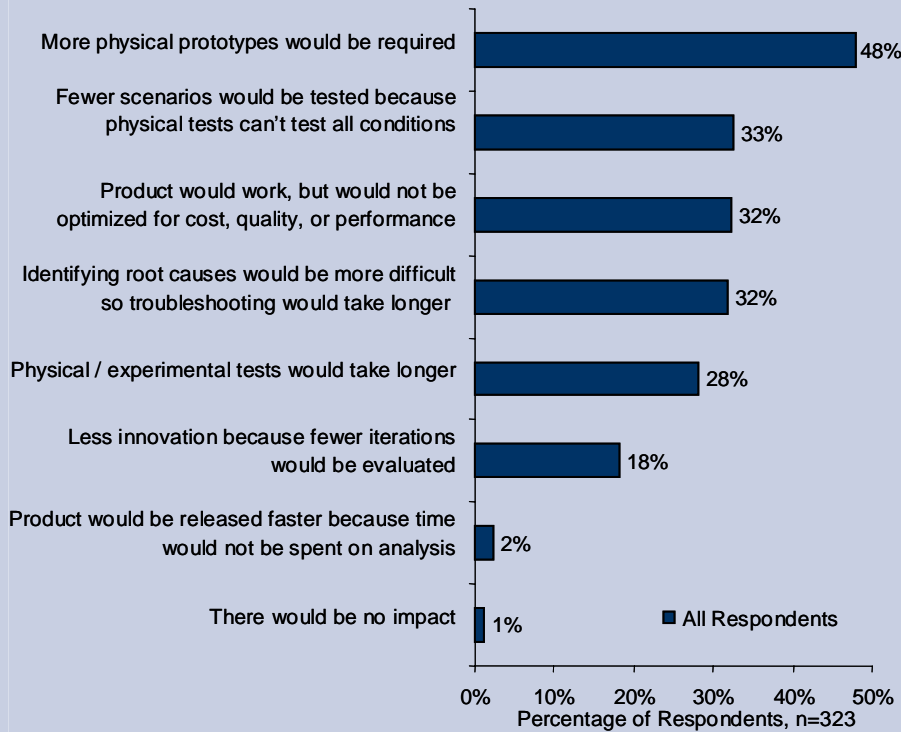
Clearly the strategies used by Best-in-Class companies provide a competitive advantage. The strategies demonstrate that it is important to take the right steps to ensure designs are right the first time and assess product behavior against a wider range of variables. This leads to the question, is CFD an important part of this strategy? Will products that are impacted by fluid and gas flow, heating and cooling, chemical reactions, turbulence, and other related physical phenomena benefit from a CFD analysis? To understand this, those using CFD were asked what the two biggest impacts would be if CFD were not used. The results are seen in Figure 6.

The vast majority of companies, 97%, see a lot of value from CFD, regardless of which performance tier they are in. CFD has the largest impact on reducing physical prototypes, but impacts many other areas as well. Interestingly, the areas it impacts affect time, quality, and cost, the top pressures driving improvements to how product behavior is assessed.

continued

Aberdeen Insights — Strategy

Figure 6: Leading Impacts of Not Using CFD



Source: Aberdeen Group, April 2011

By using CFD, a variety of conditions can be tested without incurring the cost, or experiencing time delays, needed to build a physical prototype. When problems are found, CFD results can be used to better understand how the failure occurs, which makes arriving at a solution that much faster. Because more can be done in the virtual environment, it is easier to evaluate many design iterations to arrive at a cost effective solution that will meet performance and quality criteria. Also, because more iterations can be evaluated, there are more opportunities to evaluate new innovations. Finally, because so much of the design can be validated virtually, physical test time does not need to be wasted on simple verification, but can instead focus on higher level testing.

"Improved hardware for faster run times greatly improved our use of simulation."

~ Viet Hoang, Development Engineer (E.I.T.), Alberta Centre for Advanced MNT Products

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

Chapter Two: Benchmarking Requirements for Success

Chapter One demonstrated the pressures driving companies to improve their understanding of product behavior during development and the challenges associated with it. It also described the performance benefits associated with successful approaches of obtaining insight into product behavior early on and the strategies used by the most successful companies. Chapter Two explores the capabilities and enabling technologies that Best-in-Class companies use to execute those strategies, allowing them to enjoy greater product profitability and a competitive advantage.

Case Study — Turbine Company

For a turbine manufacturer, CFD has become critical to their process. Production of a turbine is, as you can imagine, very costly and time consuming which has driven the use of CFD. A CFD Engineer at this company, acknowledges, “CFD reduces the design cycle and cost and enables optimization of the product. It allows us to optimize the aerodynamic performances, sometimes beyond what manufacturing can produce. Through its use, we are able to make design improvements that lead to cost savings and efficiency improvements.”

To achieve this optimization, CFD is used to evaluate many different configurations. Engineers can run the simulation with various different component designs and compare outputs. Key to this is setting consistent starting boundary conditions, such as ambient humidity, pressure, and temperature, across all configurations.

“It would be cost prohibitive to build more than one physical prototype, fortunately the CFD results are so accurate and reliable, testing will be done on one prototype, made from a design found through CFD simulation, with greater confidence,” said the CFD Engineer.

Fast Facts

Compared to all competitors, the Best-in-Class are:

- √ **44%** more likely to use CFD results to promote collaboration between analysts and engineers
- √ **32%** more likely to evaluate what-if scenarios / DOE using CFD analyses
- √ **32%** more likely to track shortcomings of simulations to use to improve future models

Competitive Assessment

Aberdeen Group analyzed the aggregated metrics of surveyed companies to determine whether their performance ranked as Best-in-Class, Industry Average, or Laggard. In addition to having common performance levels, each class also shared characteristics in five key categories: (1) **process** (the approaches they take to assess product behavior); (2) **organization** (defined responsibilities and access); (3) **knowledge management** (how analysis information is shared); (4) **performance management** (the ability of the organization to measure its results to improve its use of CFD); and (5) **technology** (the appropriate tools used to support assessing CFD behavior). These characteristics (identified in Table 3) serve as a guideline for best practices, and correlate directly with Best-in-Class performance across the key metrics.

Table 3: The Competitive Framework

	Best-in-Class	Average	Laggards
Process	Simulation is used to make trade off decisions		
	81%	68%	62%
	Engineers assess multiple engineering criteria simultaneously (i.e. heat and structure at the same time)		
	76%	56%	49%
	CFD results used to improve collaboration between design engineers, R&D engineers, and analysts		
Organization	Design engineers have access to CFD results		
	73%	63%	53%
Knowledge	Previous analysis results are centrally managed		
	48%	28%	27%
	Best practices for conducting a simulation are centrally available		
Performance	Shortcomings of simulation are tracked and improved		
	53%	37%	33%
	Root cause of ECOs is tracked		
Technology	47%		
	31%		
	25%		
	Technologies currently in use:		
	<ul style="list-style-type: none"> ▪ 86% CFD analysis tool ▪ 57% What-if scenarios/ design of experiments conducted with CFD ▪ 40% Input parameters varied based on probabilities ▪ 97% Structural analysis 	<ul style="list-style-type: none"> ▪ 74% CFD analysis tool ▪ 43% What-if scenarios/ design of experiments conducted with CFD ▪ 19% Input parameters varied based on probabilities ▪ 87% Structural analysis 	<ul style="list-style-type: none"> ▪ 64% CFD analysis tool ▪ 40% What-if scenarios/ design of experiments conducted with CFD ▪ 14% Input parameters varied based on probabilities ▪ 86% Structural analysis

Source: Aberdeen Group, April 2011

Capabilities and Enablers

Based on the strategies deployed to support assessing product behavior, the findings of the Competitive Framework and interviews with end users, Aberdeen’s analysis of the Best-in-Class reveals where companies must focus to improve their ability to assess product behavior when gas or fluid

"Through CFD analysis, we were able to identify a localized hot spot and problems with non-uniform temperatures. By using the simulation results, we were able to correct the problem in just three to four design iterations. This example alone proved how useful CFD can be."

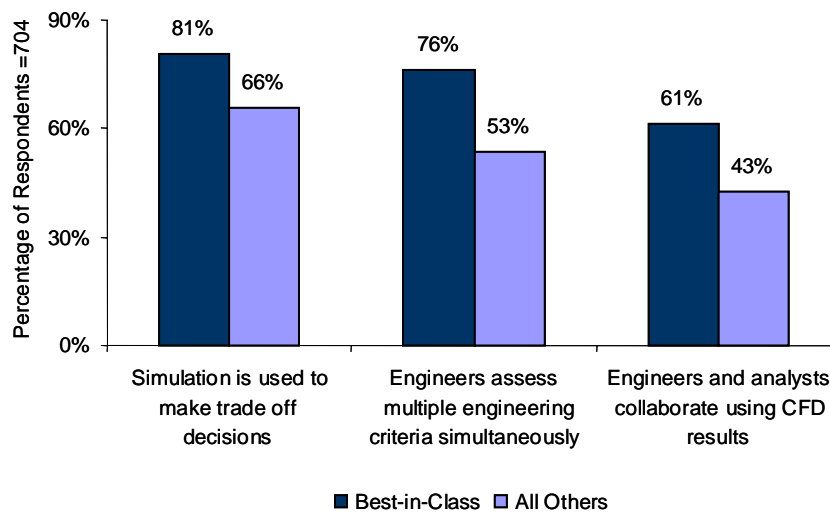
~ Anna Garrison, Faculty Research Assistant, Oregon State University

flow, heating and cooling, chemical reactions, or turbulence is involved. Processes, organizational responsibility, knowledge management, performance management, and technology all play a role in supporting this.

Process

Standard processes define how to best evaluate product behavior. The most differentiated processes implemented by the Best-in-Class are shown in Figure 7.

Figure 7: Best-in-Class Processes to Assess Product Behavior



Source: Aberdeen Group, April 2011

The Best-in-Class are 43% more likely than their competitors to assess multiple engineering criteria simultaneously and 23% more likely to use simulation to make trade off decisions. An example of this is optimizing the location of a heat sink, while minimizing weight to save material costs, yet still ensuring performance objectives are achieved. These criteria often conflict and require a deep level of insight to make the right decisions that will result in a high quality design, which is cost effective. Proper evaluation of this requires an understanding of how the different physics will impact the design as well as identifying the design sensitivity to the trade offs. Not going through this analysis could result in a higher costing product or finding a problem, such as over heating, during physical testing which causes a delay in releasing the product to market, or even worse, problems in the field that hurt the quality image of the product. These processes contribute to the Best-in-Class' ability to reduce product cost by 24% and meet cost targets, addressing the market pressure for lower cost products.

Enabling design and R&D engineers to have this insight requires collaboration with analysts. By using the CFD results to collaborate, analysts can provide guidance for conducting analyses, improving the models, or altering the design. By collaborating from the beginning, the expertise of the analyst can be leveraged early on when they have the most impact. If there

"To increase energy efficiency and reduce cost, we optimized a hermetic compressor design by analyzing gas dynamics behavior (pressures and temperatures) to minimize energy losses. This allowed us to reduce the amount of steel, and copper used in the electric motor and the electricity by the system."

~ Luis Lopez, Analysis & Simulation Expert, Tecumseh

is no collaboration and the analysts are not brought in until the end, so much of the design is finalized, analysts are limited to just finding problems rather than optimization and improving product profitability. This collaboration creates greater efficiency, while making better use of resources, allowing the Best-in-Class to reduce development costs by 19%.

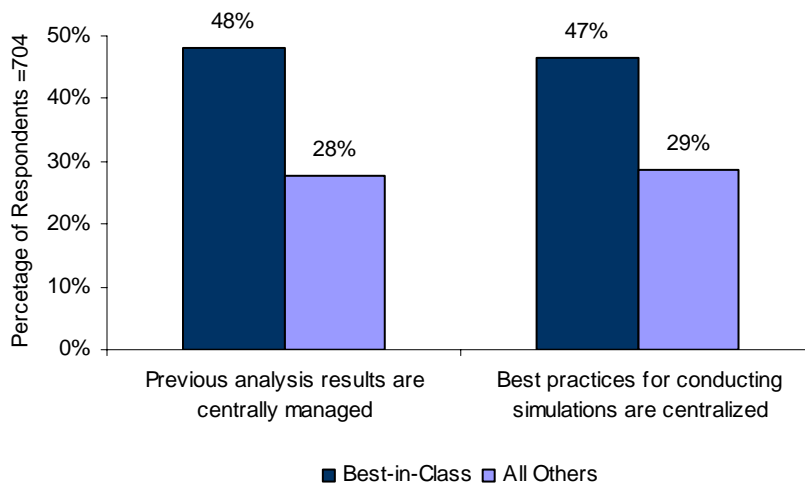
Organization

To support collaboration between design engineers and analysts, the Best-in-Class are 15% more likely than the Industry Average to provide design engineers with access to CFD results. This way they can leverage those results as they make design decisions. Consequently, they can get the design right the first time, addressing the pressures of shortened development schedules and becoming 19% more likely than the Industry Average to release products on time

Knowledge Management

Figure 8 shows the Best-in-Class capabilities to capture and manage knowledge around simulations.

Figure 8: Best-in-Class Capabilities to Manage Analysis Knowledge



"In maximizing the capability of our CFD tools, our smartest move was to employ an additional engineer with prior experience using CFD."

~ Thomas Clark, CTO, Green-Tide Turbines Ltd

Source: Aberdeen Group, April 2011

As previously discussed, collaboration between analysts and design engineers is key to Best-in-Class success. To support this, design engineers need access to CFD results which requires central management of those results. In addition, access to previously conducted analyses enables engineers to have a greater understanding of design sensitivity to certain criteria as the design evolves. In addition, it makes it easier to reuse proven models on future designs which saves time. Centrally managing results also makes them available during physical testing. Leveraging CFD results during physical testing saves time as lab technicians have guidance where hot spots

will be which makes it easier to determine the optimal location for sensors. Finally, storing previous results supports continuous improvement as new results from physical testing can be compared to simulation results to improve the accuracy of future CFD models. All of this leads to greater efficiency and allows the Best-in-Class to reduce development time by 28%.

The Best-in-Class are 62% more likely to make best practices for conducting simulations centrally available. This is yet another capability to support collaboration between design engineers and analysts. By capturing best practices and centralizing them, others can learn from the expertise of the analysts and leverage those practices to conduct their own simulations to provide directional guidance during development. This promotes a greater use of simulation, helping the Best-in-Class meet 90% of their quality targets.

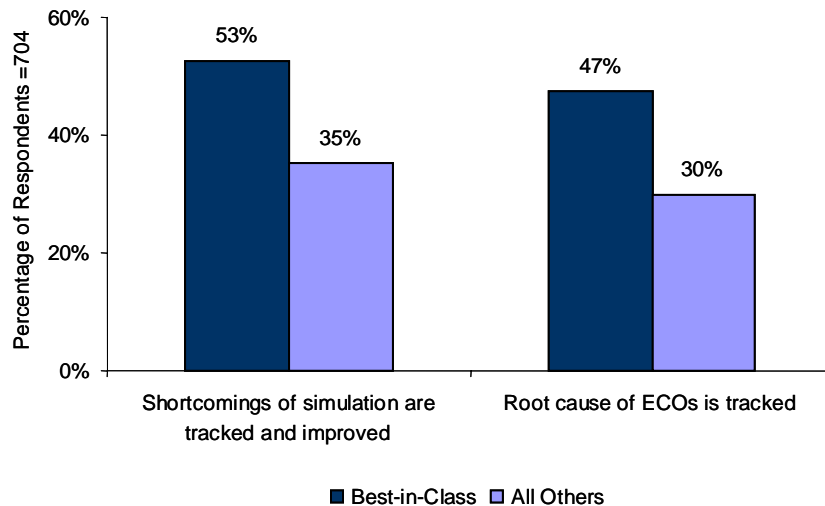
"We needed to improve the hydraulic efficiency of a centrifugal pump to beat our competition and to meet upcoming legislation. We achieved this efficiency through parameter-analysis with CFD. We are now on top of the market once again!"

~ Manager, Industrial
Equipment manufacturer

Performance Management

The Best-in-Class use performance management to support continuous improvement for the use of simulation (Figure 9).

Figure 9: Best-in-Class Capabilities to Continuously Improve Analyses



Source: Aberdeen Group, April 2011

The Best-in-Class are 75% more likely than their competitors to track problems missed during simulation. They are also 58% more likely to track the root cause of engineering change orders. By identifying these problems and understanding what was wrong, they can then apply what was learned to future simulation models to avoid repeating that same mistake again. Leveraging simulations while continually improving the models has enabled the Best-in-Class to reduce physical prototypes by 23%.

Technology

Eighty-six percent (86%) of Best-in-Class companies that develop products impacted by factors such as fluid or gas flow, heating and cooling, turbulence, chemical reactions, or other related physical phenomena use CFD. While this is an extremely high percentage, keep in mind that this survey sample was limited to respondents whose products would most benefit from CFD. It should be acknowledged that when looking at all products and the use of simulation overall, and not isolating these users, the use of CFD is much lower. As a result, they have a deeper understanding of how their product will operate in the real world environment and can optimize the design for performance and profitability. Furthering this, they use CFD to evaluate what-if scenarios or design of experiments to arrive at an optimal solution. To support the CFD analysis, they are 2.1 times more likely than the Industry Average to vary the simulation input parameters based on probabilities. By using probabilities, they reduce some of the uncertainty around the variables that will impact the design. The complexity of both the design and especially the environment bring with it a level of uncertainty that is addressed by this. Finally, recognizing that there are multiple physics that impact product performance in the real world environment, the Best-in-Class are more likely than competitors to also use structural analysis. This enables them to evaluate conditions such as the impact of over heating on the structural integrity of the part.

"Our company has benefited considerable from implementing CFD. Previously, we used the same cooling system on every product. With CFD, we can actually optimize each system."

~ Engineer, Consumer Goods

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Eighty-six percent (86%) of Best-in-Class companies that develop products impacted by fluid and gas flow, heating and cooling, chemical reactions, turbulence, and other related physical phenomena use CFD. Clearly this is a very important technology. However, what CFD software functions are the most useful? Those using CFD were asked this question and the top 5 most useful functions can be found in Table 4. Respondents using CFD ranked each function on a scale of 1 to 5 with 1 being the least useful and 5 being the most.

Table 4: Top 5 Most Useful CFD Functions for the Best-in-Class

Rank	CFD Functions	Score
1	Pressure drop	4.51
2	Temperature distribution	3.47
3	Aerodynamic lift or drag	3.29
4	Fluid mixing rates	3.13
5	Chemical concentrations	3.20

Source: Aberdeen Group, April 2011

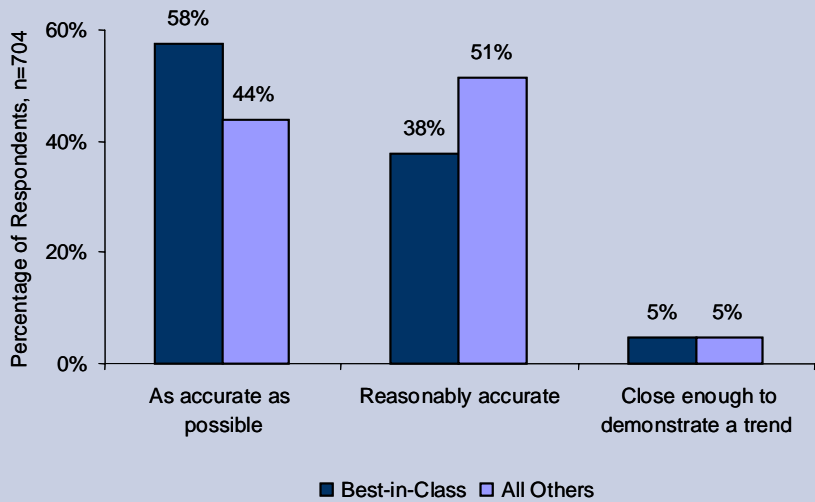
continued

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The many types of different analyses that are possible with CFD were rated very useful with pressure drop and temperature distribution being rated the most useful. The usefulness of each function will vary depending on product function, but these results show that pressure drop is widely applicable and users find it to have a large impact on the performance of their products.

When conducting simulations, often there are trade offs between simplifying the model to accelerate results and minimizing simplification to ensure the highest level of result accuracy. When model simplification is minimized, results take longer to process. Given that time is the top pressure on product development, an interesting question is, what do Best-in-Class CFD users value most, getting fast results or maximizing accuracy? As seen in Figure 10, the Best-in-Class place high value on CFD simulation accuracy and it is a major differentiator in their performance.

Figure 10: Best-in-Class Value Simulation Accuracy

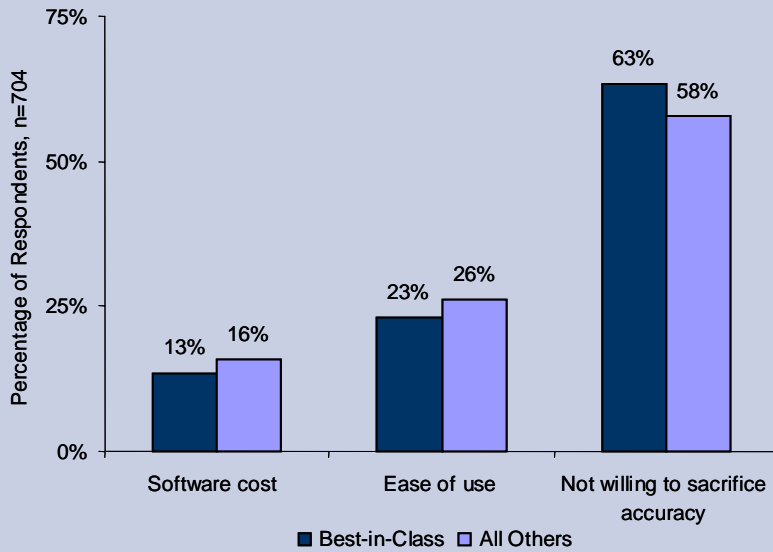


Source: Aberdeen Group, April 2011

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To take this further, CFD users value accuracy even more than ease of use and cost, with regard to how well they perform (Figure 11).

Figure 11: When looking at simulation tools are you willing to trade accuracy for:



Source: Aberdeen Group, April 2011

Chapter Three: Required Actions

Whether a company is trying to move its ability to assess product behavior from Laggard to Industry Average, or Industry Average to Best-in-Class, the following actions will help spur the necessary performance improvements:

Laggard Steps to Success

- **Capture and document best practices for conducting simulations and make them centrally available.** This promotes greater use of simulation by providing guidance to those less experienced with it while making sure those analyses are conducted correctly. The Best-in-Class are 85% more likely than Laggards to do this.
- **Track the root cause of ECOs.** By understanding the root cause of ECOs that were the result of an error or simplification, steps can be taken to avoid similar problems in the future and more specifically, improve results accuracy. Simulation models can be improved to catch future errors or additional test cases can be evaluated using simulation to avoid a repeat of the same error. The Best-in-Class are 89% more likely than Laggards to use this capability.
- **When conducting simulations, use probabilities to define input variables.** The Best-in-Class are 2.8 times more likely than Laggards to reduce risk and uncertainty in the simulation by doing this.

Industry Average Steps to Success

- **Centrally manage previous simulation results.** The Best-in-Class are 77% more likely than the Industry Average to do this and as a result save time by reusing previous models. In addition, they have a reference to improve future models.
- **Track the shortcomings of simulation to improve them in the future.** Problems missed during simulation can be used to improve future models, especially to increase results accuracy, as well as add additional scenarios to evaluate with simulation. The Best-in-Class are 43% more likely than the Industry Average to incorporate this step in their development process.
- **Vary input variables in simulations with probabilities.** This removes some of the risk associated with uncertainty in the simulation model. The Best-in-Class are 2.1 times more likely than the Industry Average to do this.

Fast Facts

The Best-in-Class are:

- ✓ **85%** more likely than Laggards to capture and document best practices for conducting simulations and make them centrally available
- ✓ **77%** more likely than the Industry Average to centrally manage previous simulation results
- ✓ **2.1 times** more likely than the Industry Average to vary input variables in simulations with probabilities

How Does Your Performance Compare to the Best-in-Class?



- Compare your processes
- Receive a free, personal PDF scorecard
- Benefit from custom recommendations to improve your performance, based on the research

Take the Assessment

Receive Your Free Scorecard

Best-in-Class Steps to Success

- **Implement Reduced Order Models (ROM).** These are simplified mathematical models that can be used to model system level behavior. Given how complex systems can be, this simplified model provides a high level view to define and understand how the system and its components interact. Twenty-seven percent (27%) of Best-in-Class companies that develop products impacted by fluid or gas flow, heat and cooling, or other related physical phenomena are planning to implement this.
- **Take advantage of predefined wizards or templates to guide less experienced users through simulations.** These support less experienced users or those who could benefit from using simulation on occasion, but do not use it every day so are less familiar with the steps. Twenty-seven percent (27%) of Best-in-Class companies report plans to implement this.
- **Implement a formal management system such as Product Lifecycle Management (PLM), Engineering Knowledge Management (EKM), Product Data Management (PDM), etc. to manage simulation data.** These systems provide a central repository for simulation, promote collaboration, ensure the right people have access to the results, and offer version control. Twenty-six percent (26%) of Best-in-Class companies are planning to implement a formal management system for simulation data.

Aberdeen Insights — Summary

CFD is an important tool when products are impacted by fluid and gas flow, heating and cooling, chemical reactions, turbulence, and other related physical phenomena. The complexity of today's products as well as the environment they operate in makes assessing product behavior and function extremely challenging. To address this, Best-in-Class companies implement a variety of strategies that support getting it right the first time. As a result, they are more likely to bring products to market on time, lower product cost, and meet quality criteria. To accomplish this, the Best-in-Class:

- Promote collaboration between the analysts and design engineers
- Assess multiple engineering criteria simultaneously
- Promote continuous improvement to perfect model quality and increase results accuracy

CFD is a key enabler to support these capabilities. It improves the accuracy in which real world behavior is assessed, enabling engineers to make better decisions that ultimately lead to more profitable products.

Appendix A: Research Methodology

Between March and April 2011, Aberdeen examined the use, the experiences, and the intentions of more than 700 enterprises whose products are impacted by gas or fluid flow, heating and cooling chemical reactions turbulence, or other related physical phenomena.

Aberdeen supplemented this online survey effort with telephone interviews with select survey respondents, gathering additional information on CFD strategies, experiences, and results.

Responding enterprises included the following:

- *Job title:* The research sample included respondents with the following job titles: Executive level manager (6%); VP/Director (4%); Manager (19%); Engineers (56%); and other (15%).
- *Industry:* The research sample included respondents from a wide cross section of industries. The sectors that saw the largest representation in the sample were (some serve multiple industries): industrial equipment (19%), automotive (19%), aerospace and defense (18%), high tech (12%), oil/gas (11%), and military/public sector (9%).
- *Geography:* The majority of respondents (49%) were from North America. Remaining respondents were from the Europe (40%) Asia-Pacific region (9%) and the rest of the world (2%).
- *Company size:* Thirty percent (30%) of respondents were from large enterprises (annual revenues above US \$1 billion); 38% were from midsize enterprises (annual revenues between \$50 million and \$1 billion); and 32% of respondents were from small businesses (annual revenues of \$50 million or less).
- *Headcount:* Forty percent (40%) of respondents were from large enterprises (headcount greater than 1,000 employees); 30% were from midsize enterprises (headcount between 100 and 999 employees); and 20% of respondents were from small businesses (headcount between 1 and 99 employees).

Study Focus

Respondents completed an online survey that included questions designed to determine the following:

- √ What is driving companies to improve how product behavior is assessed
- √ The challenges of assessing product behavior
- √ The actions these companies are taking to improve assessing product behavior
- √ The capabilities and technology enablers they have in place to support product assessment

The study identifies emerging best practices to evaluate product behavior to make better design decisions and to provide a framework by which readers could assess their own capabilities.

Table 5: 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>Pressures — 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>Actions — 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>Capabilities — the business process competencies required to execute corporate strategy (e.g., skilled people, brand, market positioning, viable products / services, ecosystem partners, financing)</p> <p>Enablers — 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, May 2011

Table 6: 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>Best-in-Class (20%) — 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>Industry Average (50%) — Practices that represent the average or norm, and result in average industry performance.</p> <p>Laggards (30%) — Practices that are significantly behind the average of the industry, and result in below average performance.</p>	<p>In the following categories:</p> <p>Process — What is the scope of process standardization? What is the efficiency and effectiveness of this process?</p> <p>Organization — How is your company currently organized to manage and optimize this particular process?</p> <p>Knowledge — What visibility do you have into key data and intelligence required to manage this process?</p> <p>Technology — What level of automation have you used to support this process? How is this automation integrated and aligned?</p> <p>Performance — What do you measure? How frequently? What’s your actual performance?</p>

Source: Aberdeen Group, May 2011

Table 7: 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 influential 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, May 2011

Appendix B: Related Aberdeen Research

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

- [Aberdeen's Cost Saving Strategies for Engineering: Using Simulation to Make Better Decisions, April 2010](#)
- [Engineering Evolved: Getting Mechatronics Performance Right the First Time, November 2008](#)
- [Engineering Executive's Strategic Agenda, June, 2008](#)
- [Complementary Digital and Physical Prototyping Strategies: Avoiding the Product Development Crunch, February 2008](#)
- [System Design: New Product Development for Mechatronics, January, 2008](#)
- [Engineering Decision Support, September 2007](#)
- [Simulation-Driven Design: Getting it Right the First Time, October, 2006](#)

Information on these and any other Aberdeen publications can be found at www.aberdeen.com.

Authors: Michelle Boucher, Research Analyst, Product Innovation & Engineering Practice, (michelle.boucher@aberdeen.com);
Colin Kelly-Rand, Research Associate, Product Innovation & Engineering Practice, (colin.kelly-rand@aberdeen.com)

For more than two decades, Aberdeen's research has been helping corporations worldwide become Best-in-Class. Having benchmarked the performance of more than 644,000 companies, Aberdeen is uniquely positioned to provide organizations with the facts that matter — the facts that enable companies to get ahead and drive results. That's why our research is relied on by more than 2.5 million readers in over 40 countries, 90% of the Fortune 1,000, and 93% of the Technology 500.

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