VOLUME 1 / ISSUE 1 / 2016

DIMENSIONS

SIMULATING BUSINESS SUCCESS

Taking Flight with AIRBUS

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EXPLORES WIRELESS CHARGING

SIEMENS
FIVE KEYS TO POWERING PRODUCTIVITY

FIREFLY
A NEW SPACE RACE

ANSYS

DIMENSIONS

IN THIS ISSUE

If you've ever seen a rocket launch, flown on an airplane, driven a car, used a computer, touched a mobile device, crossed a bridge or put on wearable technology, chances are you've used a product where ANSYS software played a critical role in its creation. ANSYS is the global leader in engineering simulation. We help the world's most innovative companies deliver radically better products to their customers. By offering the best and broadest portfolio of engineering simulation software, we help them solve the most complex design challenges and engineer products limited only by imagination.

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THE ERA OF UNBOUNDED PRODUCT OPPORTUNITY

By Mark Hindsbo, Vice President of Marketing, ANSYS

While every company and industry has its own specific set of opportunities and challenges, there is a set of common trends that impacts us all. The rate of innovation is constantly accelerating and the number of product design options has never been larger. Forward-looking companies are tackling these shared challenges and opportunities in surprising new ways — and their stories can inspire the rest of us to work smarter, faster and more efficiently in our own business pursuits.

Every company is unique in terms of its business initiatives, its products, the value it delivers to customers and the way it goes to market. Yet in today's fast-paced, hyper-competitive world, most companies share some fundamental challenges.

We have collectively faced a global recession, and as a result there has been a multi-year focus on cost. However, the rate of innovation has continued, and is perhaps the only source of sustained competitive advantage. The top priority for businesses across the world is now shifting to top-line growth while maintaining cost control.

Over the last decades, computing power and the Internet have revolutionized the world of virtual services, and perhaps have been the largest source of economic growth. With composite materials, additive manufacturing, and the incorporation of physical devices into the Internet, we are now seeing the outline of a similar revolution for tangible products. There are several of these mega-trends coming together in almost a perfect storm: From the Internet of Things, the Industrial Internet, and Industry 4.0 over cloud and Big Data, the era of (almost) unbounded product opportunity is arising.

The development we are witnessing in these areas represents a huge opportunity for product innovation and economic growth. At the same time, the challenges of increasing competition, demand volatility and cost pressure remain. The cost of product failure has never been higher, yet time to market must be reduced while maintaining quality.

As we face these common challenges, our companies have much to learn from one another. While some businesses are achieving faster market launches by eliminating traditional development steps, others are fostering extreme innovation by rethinking historic products. Still others are adding "smart" functionality to their products in a way that completely differentiates their business from would-be competitors.

As the market leader in engineering simulation, ANSYS has the privilege of working with these industry frontrunners of today and tomorrow as they redefine product development. Call me biased, but I do not believe you can develop next-generation products without the use of simulation to evaluate and optimize the increasing number of design options with a shrinking time to market.

Dimensions is a new magazine that brings together some of the best practices from these world-leading companies, to share ideas and hopefully inspire other executives and managers as you rethink your business. In this inaugural issue, you might be inspired by how Whirlpool is leveraging social media to increase internal collaboration, how Qualcomm Halo is driving both long- and short-term innovation via a multi-team approach, or how Firefly Space Systems is rewriting the rules of an entire industry. All are using engineering simulation to take advantage of the increasing breadth of product design options and using it to push further, faster, better.

The companies in this issue are global leaders in their industries and are overcoming those common business challenges with practical, executable solutions — and we know that because we support them in achieving this goal. Over the past four decades, ANSYS has provided a simulation platform and services to product development organizations at thousands of companies, including 96 of the top 100 *Fortune* industrial companies. In creating *Dimensions*, we've worked with some of these organizations to share their exciting, and sometimes surprising, best practices that go beyond engineering to address core business issues.

Whatever the specific challenges of your own organization, we believe that you are sure to learn something valuable from this exclusive look at the initiatives of other companies. We are confident that the diversity of industries, topics and viewpoints will interest, and hopefully inspire, a wide range of readers.

Creating lasting success in today's rapidly innovating, volatile and highly competitive environment is a challenging endeavor — but the good news is that there are many ways to achieve that objective. ANSYS continues to explore how mega-trends are reshaping multiple industries and to empower you with this knowledge. It is our hope that the success stories in these pages and our other communications will help you imagine new dimensions of business excellence that you can leverage at your organization.

BUSINESS SUCCESS BY DESIGN

In today's volatile and hyper-competitive business world, getting to market first with the most innovative product is often the key to success. Increasingly, it's engineering excellence that differentiates the leaders from the followers. Are your engineering teams leveraging the latest thinking and most–forward-looking practices to power your corporate success?

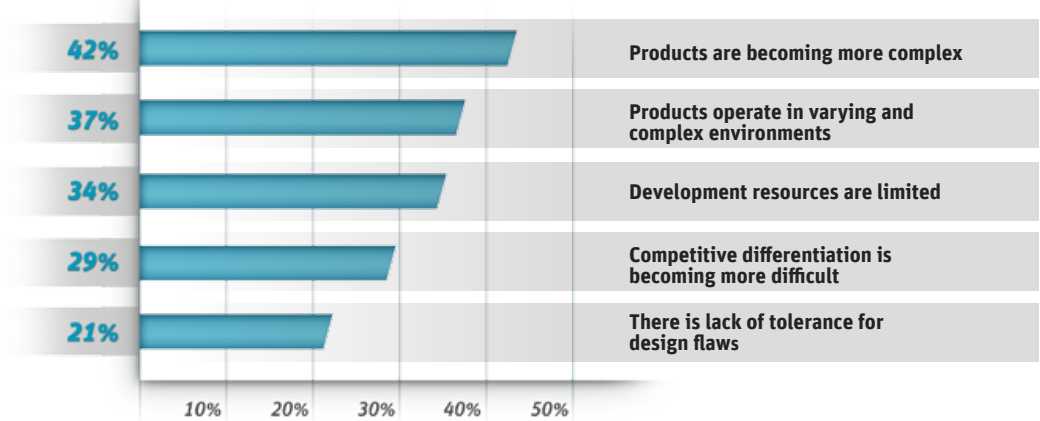
By Todd McDevitt, Director, Corporate Marketing, ANSYS

Today's industrial and consumer markets are characterized by increasingly complex products produced by a broadening distributed supply chain and consumed by an ever-evolving integrated global economy. Demand uncertainty, increasing competition and omni-channel selling have made the business climate even more challenging for manufacturers.

In this complex, challenging environment, companies that have seized leadership — like Apple and General Electric — have done so by being the first to market with truly innovative, game-changing solutions. For product manufacturers, engineering excellence is an absolutely critical component for success.

However, while engineering is a key competency, companies often overlook the importance of engineering to long-term business success. At ANSYS, we've created *Dimensions* to illuminate how inventive engineering practices can lead to top-line growth and overall business success.

TOP CHALLENGES FOR PRODUCT DEVELOPMENT



Source: Aberdeen Group, June 2014

In this complex, challenging environment, companies that have seized leadership have done so by being the first to market with truly innovative, game-changing solutions.

THE CHANGING BUSINESS OF ENGINEERING

Engineering product development has never been trivial, but today it is even more challenging to sustain engineering leadership. Not only is change constant, but the pace of change is accelerating. Products are much more complex, in many instances because they feature smart components like sensors that collect real-time performance data. Products now include the embedded software and electronics that are required to process this data, automatically improve performance, or anticipate future user needs.

Products are also more connected, sharing data and communicating with other products and systems to support the Internet of Things (IoT). For example, active automotive safety systems have evolved from systems contained within the car — such as automatic braking assemblies — to complex systems that enable vehicle-to-vehicle and vehicle-to-infrastructure communications to warn drivers of possible hazards.

Refrigerators, thermostats, gaming systems and digital video recorders have wireless capabilities so that you can control them via personal smartphones and tablets. Oil rigs, locomotives, jet engines and other industrial products are more connected, with the ability to optimize performance, minimize downtime, and improve utilization of natural resources.

The globalization of companies — and thus, their engineering organizations — means that design is a 24-hour endeavor, characterized by international collaboration and distribution of work across several continents. The trend toward connected products further complicates business practices, as companies must forge supply chains and relationships outside of traditional industry channels.

Market globalization means that most companies now have international customers who demand a steady stream of new products, often customized to their regional preferences. In response, engineering teams must develop a versatile platform for their product and then deliver rapid, frequent product variations, all without relying on additional resources — because low product-development costs lead to competitive pricing.

The Internet of Things is expanding across all industries, affecting product complexity and the need for new engineering practices.

The relentless and changing demand for innovative products, the need to further decrease time to market, and the requisite for highly distributed engineering teams and supply chains are changing how companies perform and manage engineering.

REDEFINING ENGINEERING EXCELLENCE

ANSYS works with leading businesses worldwide to support not just product development success, but the success of their overall organizations. For more than 40 years, ANSYS has provided simulation software that empowers companies to test and verify their products in a low-cost, risk-free virtual world.

Based on our collaborations with thousands of companies (including 96 of the top 100 *Fortune* 500 industrial companies), ANSYS has learned that successful engineering teams are quick to adopt innovative practices and re-invent their traditional ways of working. This requires the foresight, support and guidance of high-level executives who understand the big picture — industry trends, competitive threats, customer concerns — to ensure that changes within the engineering function reflect the highest priorities of the company. These leaders are champions of change, ensuring that their entire organization employs new, higher-impact processes and tools.

Dimensions showcases innovative companies that employ ground-breaking new practices, specifically in engineering, to address core business challenges and directly support long-term strategic success. In general, we've found that leading engineering teams focus on four key areas: improving collaboration and communication, increasing productivity and throughput, performing engineering at the systems level, and increasing the scale and pace of product innovation.

COLLABORATION AND COMMUNICATION

As John Mannisto, formerly of Whirlpool ,points out on page 19, collaboration, teamwork and brainstorming were much easier when engineering teams worked at a single location — and engineers could gather around a drafting table to collectively solve problems.

But in today's globalized business world, engineers may be trying to solve similar problems while working on different continents. Product development teams need new ways of working together to address shared problems.

Leading international companies have arrived at some innovative ways to leverage their geographically distributed knowledge. At Whirlpool, an internal social media platform called the Commons provides a unique environment in which collaboration can occur 24 hours a day, seven days a week — and accumulated knowledge can be accessed on demand.

Scattered around the globe and focused on different phases of the product development process, engineers at Qualcomm Halo (see page 12) get together virtually during weekly "coffee breaks" to exchange ideas and present progress reports to maximize the speed and productivity of Qualcomm Halo development efforts worldwide.

ANSYS supports collaboration and communication by offering a simulation platform to unify industry-leading simulation technology and to enable enterprises to manage design processes and access shared data securely, no matter where engineers are located. Cloud computing will play a critical role in fostering even greater collaboration among international engineering teams by providing easy, round-the-clock access to simulation tools, data and work in progress.

INCREASED THROUGHPUT

A hyper-competitive, innovation-driven business environment means that engineering teams need to launch the "next big thing" faster, and more frequently, than ever. But cost pressures mean that additional speed and increased throughput cannot be achieved by adding new resources.

How can engineers expect to accomplish more development work, with the same resources, in a much shorter time frame? The answer is process compression. Leading companies use a variety of approaches to eliminate time from the engineering and design phases, while still ensuring uncompromising product quality.

Recognizing the growing need to streamline processes and amplify engineering resources, ANSYS enables companies to customize simulation work processes and codify best practices. When method groups deploy a set of customized best practices for engineering simulation, even casual users can quickly complete analysis tasks accurately and support design decisions earlier. Amplifying the value of engineering simulation throughout the design teams can dramatically accelerate the development cycle without the need to hire new staff.

Leading companies use a variety of approaches to eliminate time from the engineering and design phases, while still ensuring uncompromising product quality.

ENGINEERING AT THE SYSTEMS LEVEL

Today's products are more intelligent and interconnected than ever, with software-controlled mechatronic systems that deliver advanced features to ensure safety, improve efficiency or reduce energy consumption. Systems-level engineering helps to ensure that all components will work together when the overall system is subjected to many different operating conditions and physical forces. A systems-level approach also helps engineering teams to overcome functional silos and achieve a shared vision of product performance.

Because modern jets comprise a number of increasingly complex, distributed smart systems, it's absolutely imperative for Airbus to take a systems-level approach (see page 6). By simulating the performance of entire systems in a risk-free, virtual environment, Airbus ensures safe operation under real-world conditions while protecting passengers' well-being.

ANSYS helps customers across a multitude of industries to manage product complexity, reduce software development costs, and optimize overall system performance at all design phases with model-based engineering solutions. ANSYS supports model-based systems engineering, model-based software development, and virtual system prototyping to deliver safer, higher-quality smart products to the market rapidly, while still ensuring product quality, robustness and durability once the entire system is placed into operation.

PLATFORM FOR INNOVATION

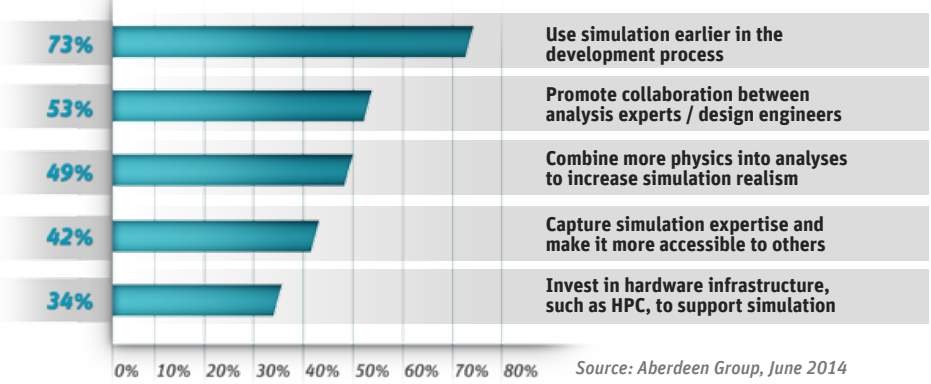
Although the bottom-line benefits of driving time and costs out of product development are important, they represent only half the picture. To truly succeed in the current business climate, companies need to drive top-line revenue growth via ongoing product innovations.

It's imperative that companies get to market rapidly, with a superior product that exceeds customers' expectations. In today's globalized market, it is also important to create customized product variations that reflect localized customer preferences. In short, companies win today by out-engineering their competitors.

When we talk about innovation, often we think of companies like Firefly Space Systems, which seeks to democratize access to space and dramatically cut the cost of space travel (see page 36).

Every business can drive innovation within its own business model and its own product suite. For example, in 2013, Gilkes — a long-term leader in power generation and engine systems — realized that emerging competitors were copying its designs and winning customer contracts. Today, Gilkes relies on advanced technologies to completely reinvent its traditional product lines and redefine customer value (see story on page 31).

TOP ACTIONS TO IMPROVE PRODUCT ASSESSMENTS



Source: Aberdeen Group, June 2014

LESSONS FROM THE LEADERS

In today's global marketplace, businesses must constantly rethink not only their products and services, but the internal processes and tools that support their success. Our world is characterized by continual change.

It is especially important to ensure that designers and engineers work with the most up-to-date, innovative practices and technologies. It's always a good idea to study what the leaders do, as a means of benchmarking your own performance and applying some valuable lessons learned.

In publishing *Dimensions*, our goal is to showcase some of the innovative processes and tools that leading engineering teams in a variety of industries use. Whatever your industry or product focus, we anticipate that the articles in this magazine will inspire you to pursue excellence and innovation in your own engineering organization.

Bruno Darboux (right), vice president, Systems General Engineering for Airbus, and Pascal Gendre (left), senior expert, Modeling and Simulation for Airbus, explain how the aerospace giant uses simulation to manage and integrate the increasingly complex, distributed smart systems that comprise the modern jet aircraft.

Dimensions: What is the biggest challenge in the aerospace industry, and how is Airbus approaching it?

Bruno Darboux: Over the past decade, systems for large aircraft have become more complex. They have transitioned from a loose coupling of systems to a more tightly coupled situation. In the past, systems were designed so that they did their own job with limited information exchange (loose coupling) with other systems. They were somewhat standalone systems. This is no longer true. Now all of the systems onboard our planes are increasingly interconnected. And they share a lot of common resources — computing platforms and interface devices, for example — which makes everything tightly coupled and quite complicated. Not only are the resources shared, but the functionality is spread across several systems.

Pascal Gendre: In addition, how a system interfaces with the real world has advanced. At Airbus, we now measure more physical phenomena, such as icing, EMI/EMC, thermal environments, material behavior and fluid–structure interaction, with more precision, and that helps interacting systems to optimize the overall flight experience. You can't fly an unstable airplane. But by using an advanced flight control system that interfaces extremely closely with the physical world, you can deliver optimum flight performances under safe conditions.

MASTERING COMPLEXITY

"Heavy and costly are not viable from a business perspective."

BD: This complexity has compelled us to put heavy and costly processes into place to develop a new airplane. But heavy and costly are not viable from a business perspective. So we have introduced — and are trying to introduce more — ways of mastering this complexity by means of advanced system engineering methods. We have already started to deploy model-based systems engineering for the successful development of the A350, and want to deploy even more for our next product developments.

Dimensions: You mentioned safety briefly. The management of embedded software to ensure its safety is obviously critical for airplanes. What processes does Airbus have in place to manage embedded software?

BD: Guaranteeing the safety of embedded software is well under control thanks to compliance to aerospace standards. This includes external standards such as DO-178C and SAE ARP 4754A, along with our own internal standards. However, there are cost and lead time challenges associated with adhering to these standards. Full demonstration of compliance is very costly, so we don't want to repeat the demonstrations 10 times, because the software evolves with each design iteration. We need fast iteration loops. And, as the design matures, we have to fine-tune our software, even during the very late stages of development, including the flight test stage.

"We have already started to deploy, and want to deploy even more, model-based systems engineering."

Various sections of Thai Airways International's first A380 jetliner were joined at the Airbus Final Assembly Line in Toulouse, France, in November 2011.

Dimensions: So you can make software changes even that late?

BD: Absolutely. This is where the value of simulation software really comes into play. Tools for modeling embedded software, such as ANSYS SCADE Suite and ANSYS SCADE Display, allow engineers and designers to express the design specifications in a formal manner. These tools generate the actual flight software in an automatic way from the models. Using this method, we can produce software with a significantly reduced certification cost as well as reduce the number of very expensive test demonstrations. Software modeling and simulation has reduced our software generation time from typically two months to as short as two days during flight tests. That is a great improvement and time-to-market advantage.

Dimensions: How does simulation fit into the development process?

PG: Considering subsystem design as a start, each design team models its own environment to address the specific questions it has to answer and to find the solution for optimal performance. In the integration stage of development, we need to combine extensive simulations in a single simulator called the "Iron Bird." This simulator must accommodate several separate systems with their different physics and ways of interacting.

Dimensions: Because an aircraft is made of many models, how do these separate models come together?

BD: It's obvious that each team needs not only its own model but also a representation of what's around it. For example, the hydraulic system team needs a good representation of the engine performance and nacelle environment on the power side, and of the landing gear extraction/retraction sequences on the consumer side. This has driven us to develop an approach through which we can share models and assemble them into a larger system.

We then run end-to-end simulations, and, depending on the results, we simply tune the control logic, or possibly iterate on the architectural design.

Airbus at a Glance

- Founded: 1967
- Headquarters: Toulouse, France
- Workforce worldwide: 58,000 (100 nationalities)
- Reach: 8,340 Airbus aircraft currently in operation

PG: Whether you want to check the kinematics of control surfaces, study human factors in cockpit design, or design and calibrate an air conditioning or ventilation system, you need to use different modeling techniques, and you must simulate lots of different combinations of parameters.

The main point is to carry out much more of the integration work upfront using modeling and simulation during the tuning of the design, and reduce the number of test points during the final testing phase with the complete aircraft on the ground or in flight.

Dimensions: What is your vision of the best way to combine physical testing with modeling?

PG: We have experts who really understand how to interpret simulation results. Most of the physical testing with the real vehicle or mock-ups is aimed at double-checking that what the simulation delivers corresponds to reality. You can then use simulation to validate the aircraft behavior in the complete design and off-design envelope.

"Software modeling and simulation has reduced our software generation time from two months to two days during flight tests."

Dimensions: What other challenges are you experiencing?

BD: At Airbus, we have very diverse, competent teams in-house, but also we have a lot of collaboration with the engineering teams of our suppliers. While we are responsible for systems architecture and integration, we contract out 95 percent of our systems' detailed design and equipment manufacturing. Five percent we do in house, 95 percent we buy. The suppliers bring technologies, supply smart design solutions, and participate as part of the integration effort. So we must exchange models with our suppliers to help us accomplish more simulation upstream and perform fewer tests on the final product.

PG: To exchange models, we need to rely on strong standards. We already have exchange standards in place like Airbus AP2633, but we cannot yet say we have a truly superior set of standards to do the job in an optimum manner. We are working on developing these standards, in an industry-wide effort; the MOSSEC initiative is an example. MOSSEC stands for modeling and simulation information in a collaborative systems engineering context.

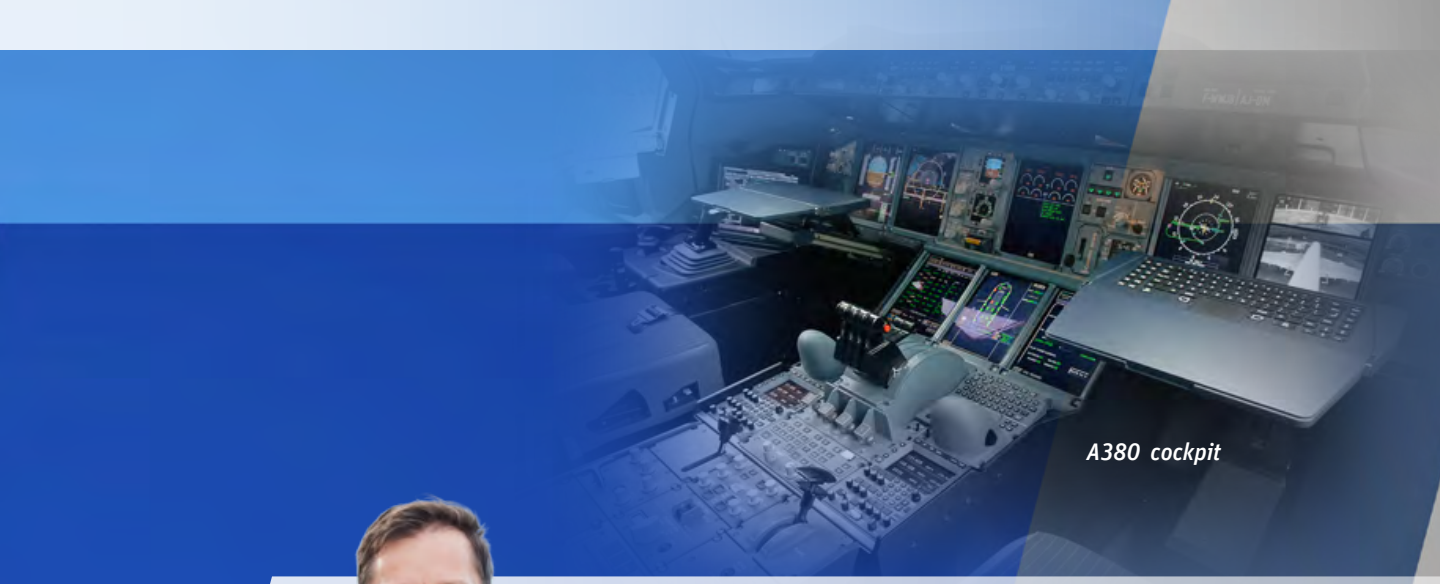
Dimensions: What technological trends do you believe will play a big role in the aerospace industry in the next five or 10 years?

BD: Innovations are not so easy to predict. However, the fields for which we generate and capture innovations are the ones that add value to our airplane customers: superior passenger experience, continual improvement of airplane performance, and seamless fleet operations.

The trend in all this is clearly digitalization — making the most knowledgeable use of data to design the best solutions. Capturing the best data and routing it to provide the best real-time services to end users is also important.

Whether you consider multiphysics optimization or the setup of distributed functionality across onboard and ground computing platforms, it is clear that modeling and simulation bring much to our business. They allow us to reduce our development cycle and costs, bringing innovation to the market much faster. And thanks to modeling and simulation capabilities, we continually develop better products, like our new A320 Neo, which delivers an improvement of more than 15 percent in fuel efficiency.

2015 ambience A350 XWB engine



A380 cockpit

Bruno Darboux has worked for Thales, ATR and Airbus. He was involved in numerous developments of civil and military platforms, in both engineering and program roles. He currently leads the definition of Airbus processes, methods and tools for systems development, and manages the teams that perform Airbus aircraft safety and qualification demonstrations.

After earning a Ph.D. in computational fluid dynamics (CFD) for aerospace, **Pascal Gendre** worked for Lacroix and Airbus. He employed modeling and simulation to develop products before devoting his efforts to developing modeling and simulation processes. He currently manages R&T projects for the modeling and simulation required for all engineering aspects of the aircraft program at Airbus.

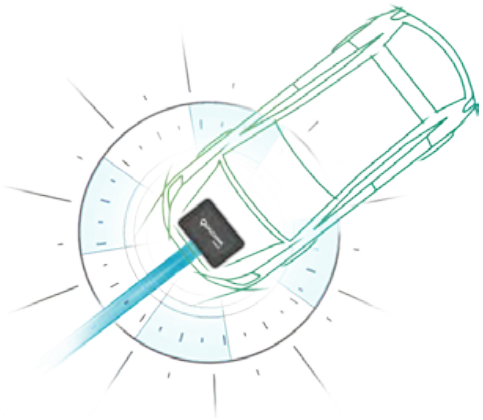
"Thanks to modeling and simulation capabilities, we continually develop better products."

CHARGING AHEAD

By Grzegorz Ombach, *Vice President, Engineering*
Qualcomm, Munich, Germany

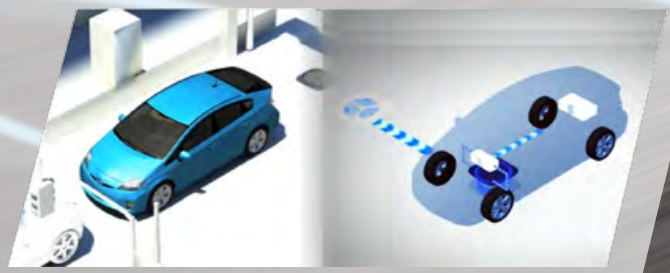
Already a leader in next-generation mobile and wireless technologies, Qualcomm Technologies, Inc., a subsidiary of Qualcomm Incorporated, is using a unique research and development approach to tackle a new frontier: wirelessly charging electric vehicles.

Qualcomm Incorporated, a global leader and innovator in wireless and mobile technologies, is committed to breakthrough innovation. In fact, Qualcomm spent $5.5 billion on research and development in wireless and mobile technologies in 2014 alone — and $34 billion over the company's life. Qualcomm licenses its developed technologies across a broad range of organizations to help diverse suppliers deliver real value to their customers. Because Qualcomm is a "fabless" business with limited production capability to manufacture products, its sole focus is on driving extreme innovation via research and development.

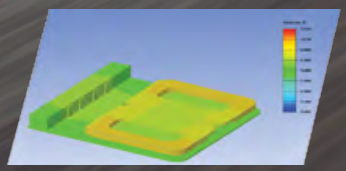


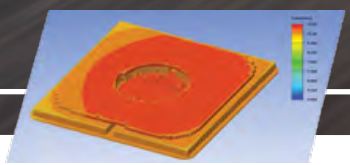
Founded as a startup 30 years ago, in many ways Qualcomm still has the culture of an agile, entrepreneurial company. New employees are hired based not only on their skill sets, but on their commitment to innovation, their passion for what they do, and their aptitude for collaboration and teamwork. These qualities are assessed during a 360-degree job interview process that includes meetings with managers and peers, and direct reports.

A flattened organizational structure makes it easy for employees to contribute ideas and have their voices heard. Risk-taking is encouraged, and mistakes are considered a necessary part of the creation process. One of the underlying philosophies at Qualcomm is: "Make a mistake by throwing the ball away — not by holding on to it too long."



Qualcomm expects easy-to-use wireless electric vehicle charging to become the way all EVs are charged in the future.





Simulation of temperature distribution for the wireless electric vehicle charging pad helps Qualcomm to innovate in developing this technology.

Wireless Electric Vehicle Charging: The Next Frontier

Qualcomm has leveraged this risk-taking philosophy to develop universal and ubiquitous wireless charging solutions for mobile handsets and portable consumer electronics devices. Today, the company is turning its attention to developing broader applications for its wireless charging technology.

Wireless charging is about to take a huge leap in scale, as kilowatts can now be transferred efficiently over an air gap of hundreds of millimeters. The Qualcomm Halo business unit, part of Qualcomm Technologies, Inc., which is a subsidiary of Qualcomm Incorporated, focuses on research and development that will capitalize on these charging improvements — resulting in the market launch of Qualcomm's innovative Qualcomm Halo™ wireless electric vehicle charging (WEVC) technology for passenger vehicles.

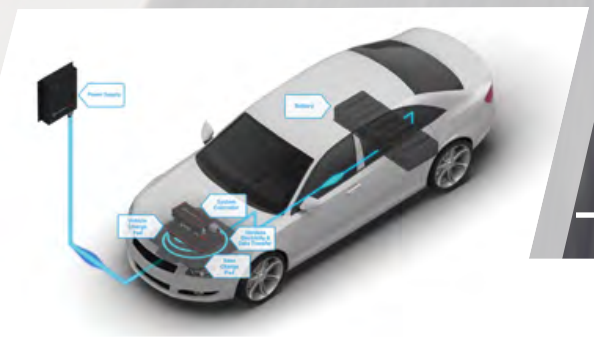
With about 70 percent of the world's population expected to live in large cities by 2050, electric vehicles hold great promise for minimizing the footprint of service stations and decreasing emissions in urban areas. However, these vehicles will not be fully embraced by consumers until charging them becomes much easier and more convenient. The Qualcomm Halo business unit was founded in 2011 to address both technology and ease-of-use challenges, with the goal of making this vision a reality.

The first consumer product based on Qualcomm Halo's wireless electric vehicle charging technology is currently expected in the next two to three years.

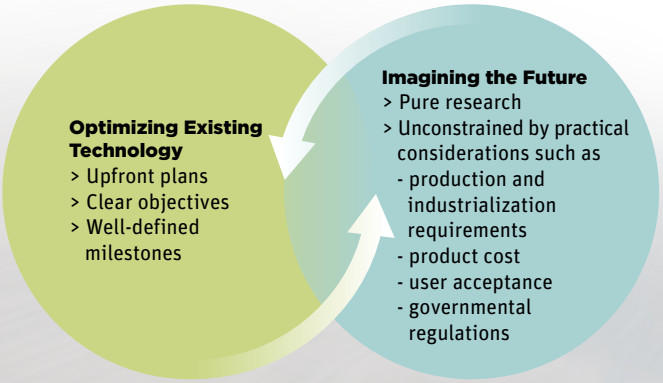
In collaboration with Auckland UniServices — the commercialization office of the University of Auckland, New Zealand — the Qualcomm Halo business unit has developed a complete wireless-charging system, including both power-transfer and ancillary technologies for safety and positioning. A final product based on this technology is currently expected to be launched in the next two to three years. With the basic research and development completed for this first-generation system, the Qualcomm Halo business unit has now formed three engineering teams with very different goals.

One team, headquartered in Munich, Germany, focuses primarily on making the incremental improvements and technology customizations that will lead to broad adoption of the first-generation Qualcomm Halo WEVC technology. The second team, based in Zurich, Switzerland, is more visionary — imagining the state of passive vehicle charging in about five years. And the final team, headquartered in Auckland, is a true think tank that focuses on the wireless charging innovations that might revolutionize the global auto industry a decade from now.

The company is turning its attention to *developing* broader applications for its *wireless charging* technology.



Why has the Qualcomm Halo business unit implemented this three-pronged approach to product development? Qualcomm's long history in consumer product innovation has taught the company that incremental product improvement and clean-sheet, visionary innovation require different skill sets and work processes. For example, while engineering simulation is a common tool for all teams, it is used very differently by engineers in Munich than by those in Zurich and Auckland.



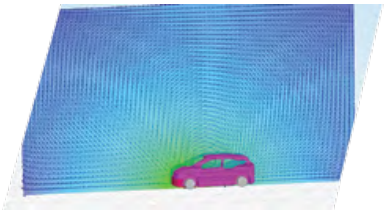
Incremental product improvement and clean-sheet, visionary innovation require different skill sets and work processes.

Munich: Optimizing an Existing Technology

Qualcomm Halo's research and development team in Munich is very similar to the engineering organization in most companies. These engineers, representing more than 20 different nationalities, are experts in practical problem-solving. They apply engineering simulation to solve a range of real-world problems that will pave the way for the launch of the WEVC systems based on Qualcomm Halo WEVC technology. The national diversity of this team is critical, as the trio of Qualcomm Halo business units wants to ensure engineering support and cooperation with the technical teams of Qualcomm Incorporated's licensees.

The Munich team is guided by upfront plans, clear objectives and well-defined milestones. Because they are solving practical problems that relate to automotive design, engineering and production, many of these engineers have years of prior experience in the automotive industry. They understand manufacturing constraints and cost controls. They interact directly with existing and potential licensees of the Qualcomm Halo WEVC technology to understand and address their real-world concerns.

Qualcomm's sole focus is on driving *extreme innovation* via research and development.



The Qualcomm Halo team in Munich simulated the magnetic field distribution around a vehicle during stationary charging.

Before WEVC systems can be released for use in residential garages and public parking lots, a number of specific questions must be answered with an extremely high degree of confidence. For example, what are the safety aspects of the electromagnetic field generated by the charging pad while in use? What if a metal object — such as a coin — is dropped onto the base pad's surface? Could such an event generate sufficient thermal buildup to start a fire or to burn someone who retrieves the object?

The Munich team leverages engineering simulation at a very granular level to understand and solve these kinds of very specific problems. Obviously, any wireless technology must be proven safe for humans and animals before it can be launched into the world — and simulation, together with laboratory testing, supports the risk-free study of relevant compliance issues.

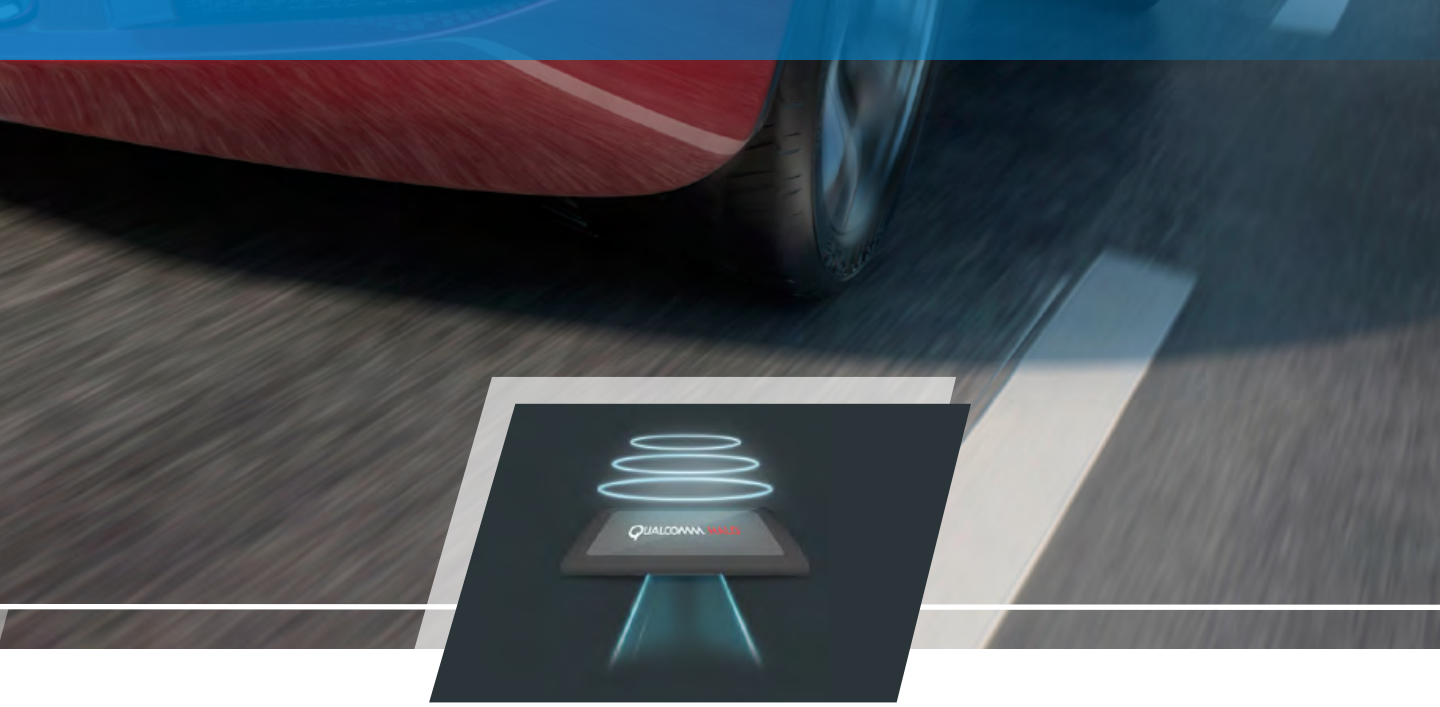
Other issues the Munich team is studying include creating interoperable solutions for diverse vehicles. WEVC technology must be adapted so that it is compatible with many vehicle types — for example, both sports cars and SUVs. In addition, the cost of the complete solution for charging must be minimized. For these and other challenges, engineering simulation is providing an easy, rapid way to get answers, troubleshoot any remaining issues, and speed the launch of the Qualcomm Halo WEVC system.

Because there are so many complex issues to consider, and much of the development work is at the system level, it would be impossible for the Munich team to develop the Qualcomm Halo technology rapidly without the use of engineering simulation.

Zurich and Auckland: Imagining the Future

The Qualcomm Halo development teams in Zurich and Auckland are envisioning what WEVC technology might look like in five or 10 years. These teams work in a "pure research" environment; they include many Ph.D.s who have spent their careers at universities or in research labs. These engineers are less constrained by practical considerations such as production and industrialization needs, product cost, user acceptance and governmental regulations. They have minimal direct interaction with Qualcomm Halo licensees, who might see their visionary ideas as impractical or cost-prohibitive in today's world.

The Swiss team is looking for various ancillary technologies, such as safety and guidance systems, which might help drivers make optimal use of wireless charging stations. The Auckland engineers are studying how WEVC technology might be embedded in roadways, so that vehicles are charged continuously as they move around urban areas. In doing so, the team investigates a variety of modes for embedding the charging stations — should they be buried? Placed on the road surface? Or flush mounted? Simulation helps these researchers examine the implications of each type of installation against a variety of



parameters: human exposure to a magnetic field, charging performance, cost and other considerations. In addition, the Auckland team is imagining the advent of futuristic automotive developments such as autonomous vehicles — and studying how dynamic wireless charging might play a role.

Both the Zurich and Auckland teams rely on engineering simulation because Qualcomm firmly believes that simulation must be injected into all stages of product development — from conceptual design to detailed engineering. However, the Zurich and Auckland teams work at a very high level, taking a systems perspective. Then, as a product idea moves through development, the engineers drill down toward more practical questions. The issues transform from "Can we embed chargers in the roadway?" to "Can we embed chargers in the roadway in, for example, London?" Simulation has proven effective in helping these teams to answer big-picture questions as well as study very specific details.

Stationary Wireless Charging for EVs

As the ideas developed in Zurich and Auckland become more feasible — and actual technologies are considered for transfer to licensees for production — these projects will be handed off to the engineering organization in Munich. There, the finest details of final product performance, production and real-world applications will be hammered out, allowing Qualcomm Halo to take advantage of the strengths of its multi-pronged engineering approach.

Encouraging Collaboration and Teamwork

The three research and development teams at the Qualcomm Halo business unit report to a single manager who monitors their progress, encourages collaboration as needed, and manages project handoffs. Originally, all Qualcomm Halo engineers met once annually to share their progress toward making WEVC a reality. But today, the global engineering team benefits from more frequent, informal discussions.

Qualcomm Halo engineers from around the world meet on a weekly basis via an online forum called the "coffee break." Via phone or video conferencing technology, these engineers share simulation results, engineering drawings or PowerPoint® slides with their peers. Qualcomm Halo coffee breaks are aimed at solving practical problems, establishing best practices, and supporting continual improvement. For example, one engineer's recent suggestion about upgrading a set of office applications on all the desktops led to a 30 percent reduction in simulation processing times for the entire global team.

About Grzegorz Ombach

Dr. Grzegorz Ombach is vice president, Engineering, at Qualcomm, with responsibility for research and development of Qualcomm's wireless electric vehicle charging technology. Ombach joined Qualcomm in April 2012 from Brose Fahrzeugteile, where he managed the design of automotive electric drive systems as director of Advanced Development Drives. He holds an M.Sc. in Electrical Engineering from the Technical University of Lodz, Poland, and a Ph.D. in electrical engineering from the Silesian University of Technology, Poland. Ombach has authored more than 70 papers and holds more than 25 patents (awarded and pending) on various automotive electrical systems.

Qualcomm firmly believes that *simulation* must be injected into all stages of *product development* – from conceptual design to detailed engineering.

Qualcomm works with automakers and their suppliers to offer WEVC systems that are optimized for each vehicle and that meet their critical design criteria.

These informal meetings reinforce Qualcomm's entrepreneurial culture by demonstrating that every employee's input is valuable. No matter what their role or location, all Qualcomm Halo engineers are invited to join these weekly roundtables and have their voices heard.

Bringing the Future Closer Every Day

At Qualcomm, making WEVC a reality is an exciting mission in which employees are proud to participate. Qualcomm has worked hard to create an elite engineering organization that is committed to keeping WEVC technology development on track by leveraging best-in-class technology tools and best practices in simulation. Qualcomm's corporate goal is to bring the future closer every day, and the Qualcomm Halo business unit is most certainly aligned with that objective.

While it's an expensive proposition to have three distinct research and development teams, in Qualcomm's view this approach is essential to maintaining technology and market leadership over the long term. Nearly every company looks at a two- or three-year horizon, focusing on near-term market launches. But Qualcomm believes that true leadership will be achieved only by those who take a longer view and begin acting on that vision today.

Looking over a 10-year horizon requires patience. Many ideas will be considered and rejected — a process that goes much faster with simulation but is still a time-consuming endeavor. However, in the end, the rewards are well worth the investment.

QUALCOMM HALO™

Qualcomm at a Glance

- **2014 revenues: U.S. $26.49 billion**
- **Number of employees: 31,300**
- **Headquarters: San Diego, California, U.S.A.**

Whirlpool Engineers Get Social

After finding his dad's World War II shipmate via social media, former Whirlpool manager John Mannisto had an epiphany: *Why aren't we using social networking technology to connect with our colleagues at work?*

Today the Whirlpool Commons has become a virtual collaboration and meeting space for hundreds of the company's engineers located in every corner of the world.

By Dimensions *Staff*

Whirlpool Engineers Get Social

Few engineers today remember the drafting board, which once had a central role in the engineering department. "Big as a conference table, it often got used that way," noted John Mannisto, former engineering director for simulation-based design at Whirlpool Corporation. "Working in a huge open space, engineers would gather around one another's drafting boards throughout the day — solving a problem together, contributing different viewpoints, or collaborating on a brand new design."

Photo courtesy Gilkes.

While John Mannisto is too young to have worked at a drafting board, he still mourns its demise. "Computer-aided design and engineering have so many obvious benefits, but we lost something important when engineers moved from open workspaces to offices and cubicles, with everyone focused on their own computer screens," he said. "We lost an easy, natural way to collaborate and share knowledge."

In his role at Whirlpool, Mannisto managed a 140-person global simulation team that spans North America, South America and Asia. Historically, groups came together once a year to meet in person and share results with one another, but Mannisto was looking for a simpler, more flexible way to encourage collaboration — not once a year, but every day. The answer came to him during a pivotal personal journey.

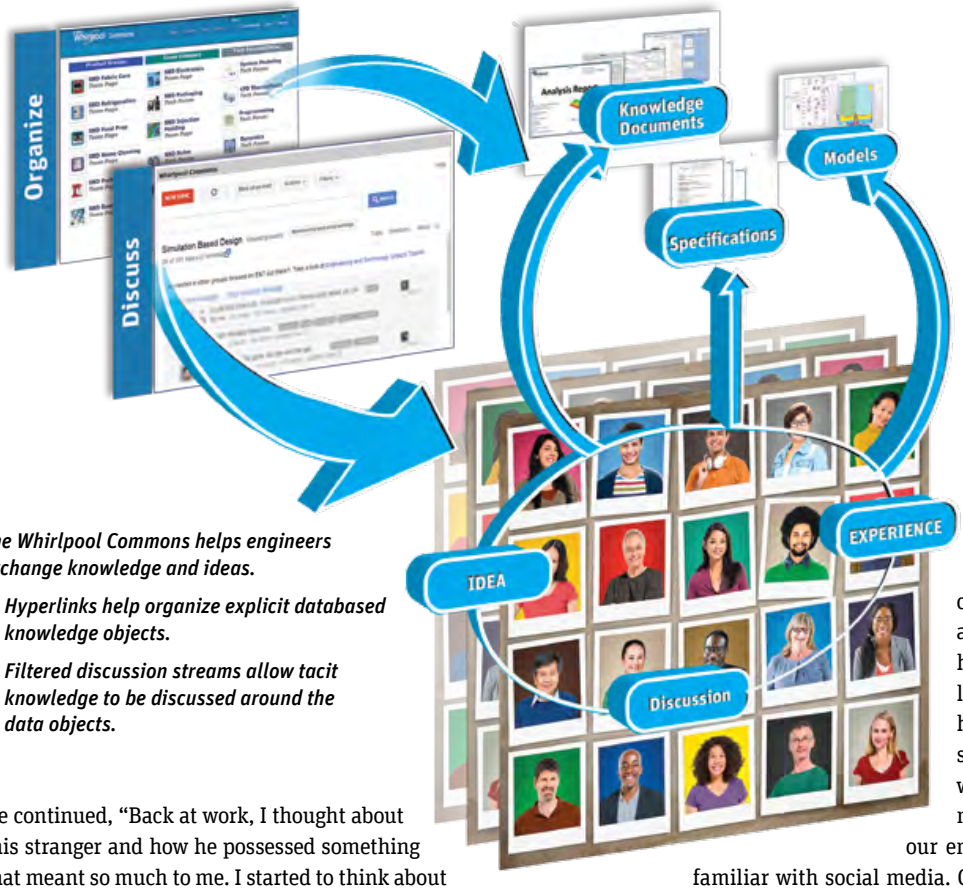
An Unlikely Connection

After his father, Walter, died, Mannisto felt compelled to learn more about him, especially his service on U.S. Navy destroyers during World War II. An Internet search led to a website where he could identify his father's shipmates on the USS Beatty and the USS Bearss. Then he contacted them by email to see if anyone recalled serving with his dad.

"The emails started coming in right away, and at first it was discouraging because no one remembered him," said Mannisto. "Then someone named Frank emailed me to say he had been my dad's shipmate. Here was this stranger who lived hundreds of miles away, who had vivid memories of my father when he was only 22 years old."

Frank visited Mannisto and happily shared his photos and memories of Walter. Then, as Frank was preparing to leave, something amazing happened. "Frank pulled out this piece of paper that he had kept for 50 years. It was a portrait of Frank that my dad had drawn one day when they were bored on the ship. Frank said, 'I always wondered why I kept this, and now I know why. It was meant for you.' It was an incredibly emotional experience, to touch this drawing that my dad had produced as a young man. And social media made that moment happen," said Mannisto. "It had to be the most unique case of 'document retrieval' ever, and it completely changed my perspective."

> **“Social media can fundamentally change the way your team *collaborates* and *shares knowledge*, shaving hours and days off the development cycle.”**



The Whirlpool Commons helps engineers exchange knowledge and ideas.

- *Hyperlinks help organize explicit databased knowledge objects.*
- *Filtered discussion streams allow tacit knowledge to be discussed around the data objects.*

He continued, “Back at work, I thought about this stranger and how he possessed something that meant so much to me. I started to think about all the valuable expertise and information that were distributed across our global team, and I wondered if somehow we could use social media at Whirlpool to share knowledge in a more effective way.”

Launching a Revolution

Fortunately, Whirlpool had an intern named Alex Otten who was looking for a summer project. He showed Mannisto a web page he had created as a vehicle for his fellow team members in the FIRST Robotics Competition to collaborate and share information. Mannisto asked if Otten could create a similar forum for Whirlpool’s simulation users. Otten used open-source software to create the “Whirlpool Commons,” a virtual conference room and collaboration space where members of Mannisto’s geographically dispersed team could post questions as they worked on simulation problems.

When he saw Otten’s prototype version of the Commons, Mannisto requested a few changes. “It was actually too sophisticated,” he recalled with a laugh. “I told Alex he needed to remove some of the bells and whistles to make it more accessible to our employees who weren’t familiar with social media. Once the site was simple and straightforward enough, we were ready to go.”

When the Commons forum was launched in the summer of 2013, the reaction was overwhelming. “It was like lighting a fire near a powder keg,” said Mannisto. “I would get a personal email every time a new user signed up. My email was pinging every few minutes. It was clear that there was a huge interest in sharing knowledge and collaborating. People from outside our department asked if they could join. We quickly had 500 users, and you could see the questions — and answers — just pouring in. Experts were sharing advice on modeling condensation, combustion, multiphase flows — the complex simulation problems we work on every day.

“You could immediately see the value that was being created,” added Mannisto. “For example, an engineer in St. Joe might

"Our philosophy is to *'crowd source'* as much as possible. It's hard to truly *innovate* if only a *few people* are invited to the discussion."

be trying to import PTC Creo® files into ANSYS Workbench — while someone in India had already solved that problem. By posting the question on the Commons and getting an answer within minutes, the engineer in St. Joe is saving hours of time that could be devoted to another task. Those kinds of exchanges started to occur every day.

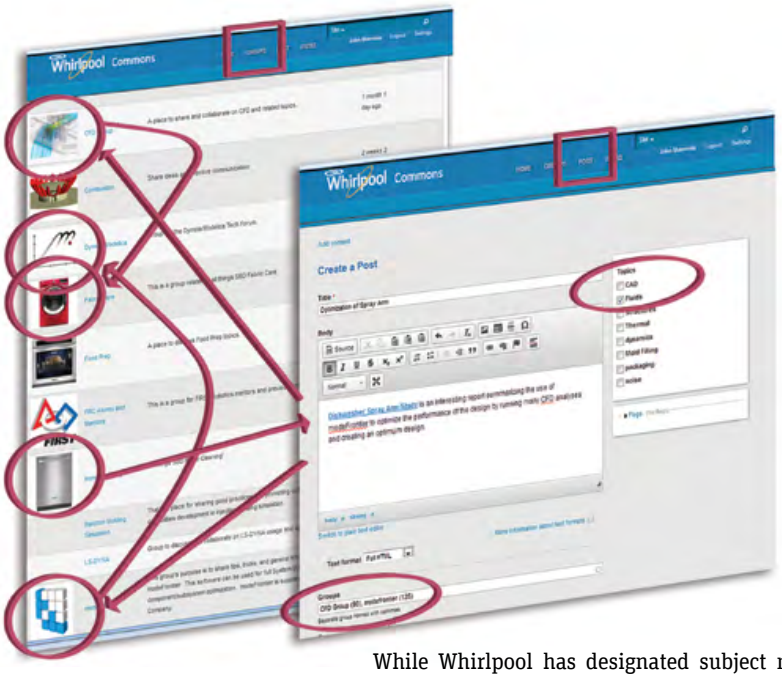
"I guess it might surprise people that an engineering department in a $20 billion company would launch a 'grass-roots' social media forum created by an intern using open source software — and it's not a strategy Whirlpool would use for any external social media initiatives," Mannisto noted. "But I think that was one of the keys to the Commons' success. No one had to use it. There were no rules; it was a bit of a free-for-all. But that got people excited, and they wanted to be part of it. It was like the early days of Facebook."

A Cultural Institution

In 2014, the Whirlpool Commons moved to the Google platform, which is used across Whirlpool Corporation — signifying that this upstart forum had become a cultural institution. Each day, Whirlpool engineers around the world use this social networking tool to connect, solve complex problems and brainstorm.

Recently, Mannisto observed as six expert engineers from across the globe came together virtually to discuss how they could speed up parameterization for computational fluid dynamics (CFD) analysis — which is a critical factor in optimizing the performance of many Whirlpool products. "These people had never met in person. One was working on a washer, one a dryer, one a cooktop. They exchanged ideas over 11 days. You could see them working out solutions, day by day. Six people were talking, but 80 people were watching the conversation and learning silently about CFD parameterization," Mannisto explained.

"Now imagine if we tried to duplicate that in the physical world," he continued. "Can you envision flying in 86 people for an 11-day meeting? Having collaborated by both methods, I can tell you that fiber optics is a lot faster, cheaper and more effective than air travel."



The Commons allows engineers to exchange ideas easily and share information between groups to accelerate innovation and enhance efficiency.

Whirlpool engineers also share simulation models and tutorials via links posted on the Commons. "If someone figures out a combustion modeling problem, that's applicable to both dryers and cooktops," Mannisto stated. "Why not put that knowledge out there where everyone can benefit from it?" Mannisto emphasized that, because the Commons resides on Whirlpool's Intranet, protected by a firewall, there are no restrictions on what can be posted or any concerns about information security.

"The Commons is content light, link heavy," he continued. "It's not so much a repository for data as a channel to find the information you need. For example, a typical entry might be, 'I just finished this body of work on dishwasher spray arms, stored in Windchill/Google Drive, and here is the link.' Later, when someone is searching for 'dishwasher spray arm,' they will surely find that conversation and that body of work. In addition to functioning as a virtual conference room, the Commons is a search engine for engineering insights."

While Whirlpool has designated subject matter experts in certain simulation topics, Mannisto likes the idea of inviting many people to contribute. "Sometimes knowledge comes from unexpected places," he noted. "When you force discussions to occur through specific channels, you limit what can be discovered. Our philosophy is to 'crowd source' as much as possible. It's hard to truly innovate if only a few people are invited to the discussion."

> **"Don't make *social networking* something your team is mandated to do. *Pull them*, don't push them. Make it easy."**

Whirlpool engineers also have their own personal workspaces with no rules about what they post there. These "scratch spaces," as Mannisto describes them, help engineers to track projects, organize their work or jot down their ideas — the virtual equivalent of having Post-it® notes scattered on a desk. "Individual scratch pages can function like incubators, allowing ideas to grow over time," explained Mannisto. "An engineer might be using this space for a project, developing ideas on both products and simulation processes. Later, the engineer realizes this is good, reusable information, and this page gets incorporated into Whirlpool's formal knowledge bank. Personal workspaces reinforce the idea of working through the knowledge, as opposed to creating it as a separate task."

"Social media is one of the lowest-cost tools available to engineers, infinitely more *flexible* and *efficient* than most off-the-shelf project management software that's out there today."

Building Your Own Social Network

What advice would Mannisto offer to other engineering teams looking to leverage the power of social media? "I don't think you necessarily need to have a younger employee spearheading the effort, but there are people in every company who are naturally comfortable with technology and social media — whether they're millennials or Facebook super-users," Mannisto pointed out. "Pay attention to how people in your office are using social media in unique ways, and ask them for their input. Their creativity might surprise you."

Mannisto also emphasized the value of flexibility and openness. "Don't make social networking something your team is mandated to do," he advised. "Pull them, don't push them. Make it easy. Put the software right on their desktops and keep protocols to a minimum. Don't have an administrator, and don't track the time employees are spending on this social networking. Let them learn at their own pace. If something's not working, don't be afraid to change it and keep going."

While Mannisto has no formal metrics to measure Whirlpool's return on investment in the Commons, he knows that it's significant. "Social media is one of the lowest-cost tools available to engineers, infinitely more flexible and efficient than most off-the-shelf project management software that's out there today," he said. "Yet it can fundamentally change the way your team collaborates and shares knowledge, shaving hours and days off the development cycle. All you have to do is watch the conversations that happen every day on the Commons to know that it's adding enormous value here at Whirlpool."

ABOUT JOHN MANNISTO

John Mannisto served as engineering director for Simulation-Based Design at Whirlpool Corporation from 2009 to 2015. Prior to that, he directed the activities of an engineering team performing design support as director of Structural/Thermal Engineering Services at CD-adapco. Mannisto has also worked as an engineer for both John Deere Rotary Engine and Lockheed Electronics. He holds B.S. and M.S. degrees in mechanical engineering from Rutgers University.

Whirlpool® CORPORATION

Whirlpool at a Glance

- → **2014 revenues: $19.9 billion**
- → **Number of employees: 100,000**
- → **Headquarters: Benton Charter Township, Michigan, U.S.A.**

5 KEYS TO POWERING PRODUCTIVITY

By Roland Sievert, Engineering Manager, Generator Development, Siemens Power and Gas, Muelheim, Germany

The generator product development group at Siemens Power and Gas faces significant challenges in meeting stringent customer demands for delivery speed and quality. The team's goal is to increase customer value and productivity, without adding more resources. In designing complex rotating machinery, how does this team balance uncompromising product quality with rapid delivery of its systems — while keeping personnel costs reasonable? Roland Sievert shares five strategies for boosting engineering productivity.

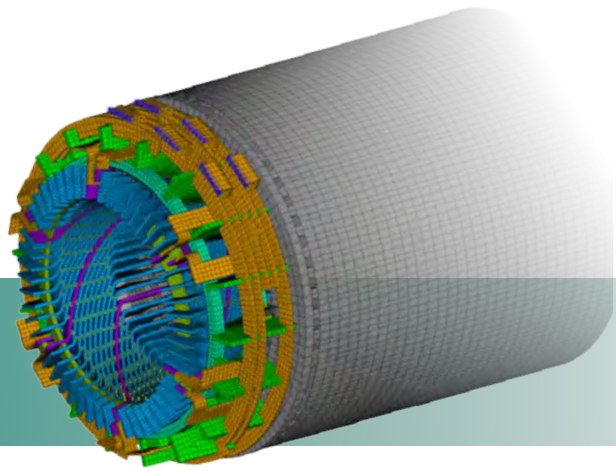
The Siemens generator business is part of the company's Power and Gas division, which supplies utilities worldwide with high-reliability, high-performance rotating power equipment. At its facility in Muelheim, Germany, engineers develop and enhance a comprehensive portfolio of turbo generators for large-scale power generation applications up to 2200MVA.

Backed by a 100-year history, an installed fleet of more than 1,300 units and efficiency levels up to 99 percent, Siemens generators are known for uncompromising product quality. In an industry where warranty expenses can be enormous and power outages can cost up to $1 million per day, Siemens' engineers cannot afford to make errors. For this reason, the company has invested in attracting the industry's best talent and assembling a portfolio of advanced engineering technology solutions that support creativity and productivity.

Today, the global power generation industry is characterized by strong competition. Large multinational companies are making significant investments in this sector. Original equipment manufacturers (OEMs) like Siemens are also facing tough competition and new challenges. Generators produced by Siemens are large, and they are also time-consuming and expensive to build. The engineering phase is a natural target for compressing the overall product delivery cycle time.

While facing tighter deadlines, the development team also provides diverse customer services. In addition to developing highly customized, clean-sheet generator designs or technologies, Muelheim engineers produce systems using off-the-shelf components to minimize complexity. All components need to operate together perfectly to meet or exceed various exacting performance needs. Plus, as Siemens' fleet of existing generators in the field ages, this same engineering team provides increasing maintenance, repair and refurbishment services.

How does the Muelheim team balance all these priorities, while still delivering the high quality demanded by the global power generation industry? Over the past several years, the management team at Siemens' generator business has worked hard to amplify the productivity of this highly skilled development team. Based on these efforts, Siemens' engineering managers have identified five keys to achieving higher productivity.



Simulation of the generator stator core system demands a real multiphysics approach using ANSYS simulation due to electrical field forces, heat generation, conduction and heat transfer as well as mechanical integrity assessment (e.g. during a short circuit) and for modal analyses.

How does the team balance priorities, while still delivering the high quality demanded by the global power generation industry?

1 IMPLEMENT

A FLEXIBLE, FLUID TEAM STRUCTURE

On any given day at Siemens' generator business, engineers are focused on a number of competing priorities. To meet all these demands simultaneously, Siemens has created an agile, fluid organizational structure. A number of "priority teams" are always dedicated to critical projects, such as getting a customer back online in the wake of an outage. But the staff members not assigned to a priority project are flexible, changing assignments as projects evolve and personnel needs change. Experts in mechanical engineering, electrical engineering and other specialized disciplines rotate among different teams as their knowledge is needed.

To support this type of agile, ever-evolving engineering, Siemens has arrived at some general staffing and technology principles. First, the majority of staff members should have a range of general skills that make them extremely versatile across teams. Engineering simulation is a specialized skill for many development teams; however, at Siemens Generators about half of the engineering staff uses simulation software frequently.

In addition, the platform of engineering and design tools should make it easy for team members to collaborate on projects, even across different physics disciplines. For the Muelheim team's many simulation projects, a custom simulation base host governs most of the engineering data. This one-dimensional (1-D) host provides and receives parameters from ANSYS Workbench. Workbench provides a common, user-friendly numerical analysis platform where team members can converge, build shared models and hand off design concepts. This shared technology environment works with the governing master data host to ensure that everyone is speaking the same language and working toward the same objectives, even as individual team members come and go.

SIEMENS AT A GLANCE

- → 2014 revenues: 30.9 billion €
- → Number of employees: 343,000
- → Headquarters: Munich, Germany

2 CREATE
A SINGLE VIEW OF PROJECT STATUS

When an engineering organization is balancing multiple priorities and members are shifting among teams, it is critical that managers have complete visibility into the status of every project. The generator engineering team uses a software product called Concerto to visualize and monitor the many projects underway at any time. Regularly, project managers report their teams' progress in Concerto, including vital details such as milestones achieved, deadlines missed, and the availability or consumption of any "buffer" time that has been created during the design process.

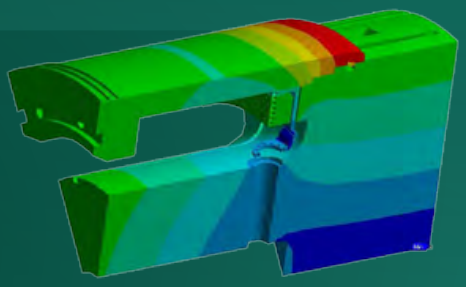
On at least a weekly basis, top engineering management takes corrective actions, such as re-assigning a specialist if a particular team is falling behind or if another team is way ahead of schedule. In making these decisions, managers weigh the strategic importance of each project to the company, ensuring that key customers are not disappointed and technology development projects are not compromised.

There are many software tools available for monitoring project progress, but the key is to have a system in place that creates complete visibility. A systematic, technology-based approach ensures that all decisions are made on a factual basis, with a comprehensive view of the whole engineering workload. These decisions are much higher in quality than those made on an ad hoc basis, or based on who is knocking on a manager's door and asking for help. By implementing a formal project-tracking system over the past three years, Siemens Generator has maintained the on-time delivery rate for engineering projects at well over 90 percent — while doubling the number of completed projects.

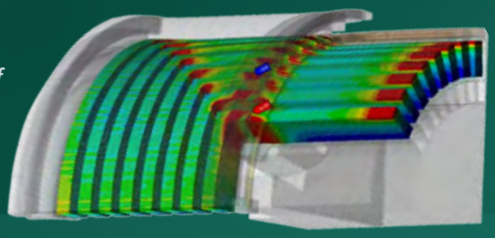
3 DRILL DOWN
ONLY AS NEEDED

In the earliest stages of generator design, a full-blown, 3-D, multiphysics transient simulation of the complete product is not only unnecessary, it consumes a disproportionate amount of resources. While Siemens' finished systems are incredibly complex, the engineering team begins by working in an in-house 1-D design environment that Siemens created using custom software code. This allows engineers to quickly pre-optimize much of a product's geometry before moving on to more sophisticated, more exacting 2-D and 3-D modeling.

As projects move through the design pipeline toward completion, Siemens engineers drill down deeper and deeper to ensure final product quality and robustness. Accuracy is increased only as it adds relevance and value. Instead of relying on a single tool and a single level of design detail, Siemens Generators has created a broad toolkit, including its custom 1-D environment, that makes the best use of limited engineering resources — but is still capable of obtaining higher-fidelity results when needed.



Assessment of stress and displacement of conductors underneath the retaining ring. Siemens engineers use ANSYS structural software to determine shrink fit, heat conduction, material combinations and in-depth mechanics due to the rotating system.



Radial displacement of retaining ring mounted on rotor body

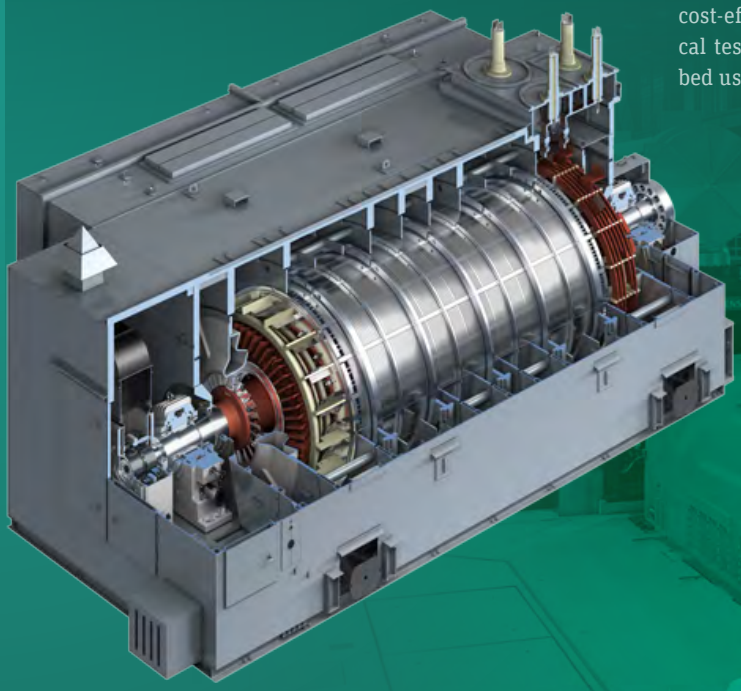
Accuracy is increased only as it adds relevance and value.

4 APPLY PHYSICAL TESTING STRATEGICALLY

Just as the engineering team at Siemens' generator business limits its use of full-blown 3-D simulation, team members deploy costly, time-consuming physical prototyping and testing only when it makes strategic sense. Siemens has constructed a large, one-of-a-kind generator test bed where systems are verified before being delivered to customers. When a company invests in this type of world-class resource, it can be tempting to use it frequently and perhaps over-rely on it as a quality check. To minimize the costs of both testing and physical prototyping, Siemens relies on simulation to not only provide early proof of machine performance, but to validate and calibrate predictive engineering methods.

Over the years, engineering simulation has proven highly accurate in predicting system performance, eliminating the need for multiple rounds of physical testing. When physical testing is needed, simulation allows Siemens engineers to use it in a very targeted manner, based on specific areas of concern identified in the virtual design space — such as regions of high mechanical stress or temperature.

When a finished generator design makes it to the test bed, engineers know exactly which areas to investigate and how to investigate them — the result of early planning and strategic thinking. And, if problems are identified in testing, targeted follow-up simulations help to address those issues quickly and cost-effectively. At Siemens Generators, simulation and physical testing work together in a closed-loop cycle, with the test bed used only when it adds customer value.



Development teams need to examine and re-examine even their most foundational processes.

5 WORK SMARTER

When an engineering team is working quickly and under constant pressure, it's easy to fall back on the philosophy of "That's the way we've always done it." However, this is contrary to increasing competitiveness over the long term via innovation and continual improvement. Development teams need to examine and re-examine even their most foundational processes to continually drive time and costs out of the design cycle. When managers shine a spotlight on daily work processes that have been accepted for years, the results can be surprising.

For instance, engineers at Siemens Generators once hand-typed a multi-page electrical data sheet for each project according to internal customer standards, which was very time-consuming. Recognizing that this was a major source of inefficiency, the Siemens team standardized this form by integrating the various customer requirements. An online version made it very easy for engineers to populate the form for each project with just a few mouse clicks. Now electrical specification happens in seconds, not days. Because the old way's resulting inefficiency impacted every downstream process, this single improvement has saved the generator business substantial lead time.

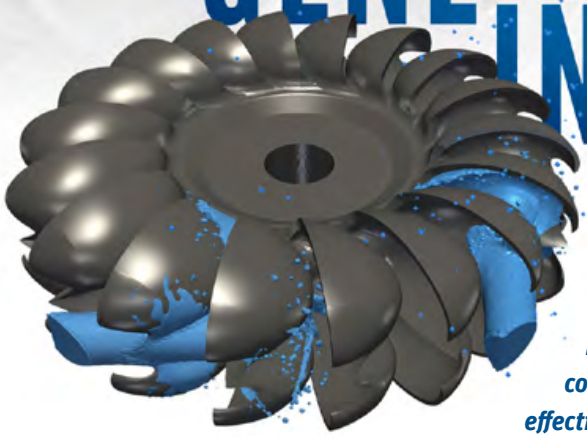
As another example, when 3-D designs are created, preliminary data is passed on for numerical analysis. As both physical design and numerical modeling continue in parallel, the design often evolves and does not match the numerical model anymore — increasing design uncertainty and decreasing the model's value. To ensure consistency, the engineers involved need to convene and verify the model's validity two times a week, even if they are working in different parts of the world. The engineers also agree on the subsequent action, with a focus on both quality and schedule. On many occasions, this saves weeks of rework and adds quality to the design at the same time — for no additional cost.

It's likely that every engineering team has institutionalized processes that have not been examined, and optimized, for years. By taking an objective look around their engineering organizations, managers may be able to identify and eliminate these kinds of hidden inefficiencies. Changing old, outdated ways of accomplishing daily tasks can power significant increases in engineering productivity, often at little or no financial investment.

ABOUT THE AUTHOR

Roland Sievert earned a master's degree in mechanical engineering in 2002 and a Ph.D. in fluid flow mechanics in 2006 from Ruhr University in Bochum, Germany. He went to Siemens beginning in 2002 as a doctoral student and was hired as a steam turbine development engineer in 2006. Three years later, he became section manager in steam turbine development, and in 2012 he was named department manager in generator engineering.

GENERATING INNOVATION



A world leader in small hydropower systems and engine cooling pumps, Gilkes built a long history of success based on proven products. In 2013, executives recognized that, to maintain leadership, product innovation was needed. By building in-house expertise in engineering simulation, the company is re-inventing its product line, both quickly and cost-effectively. This successful 162-year-old business has a few lessons for other companies targeting major innovation.

By* Dimensions *Staff

Increasing environmental regulations, coupled with government incentives for green products and systems, have created dramatic changes for engineering teams in many industries. For example, in the power generation industry, more plants are being constructed using wind, water and solar power, which has created a fast-growing market and a new set of customer needs. Product development teams focusing on engines or engine components face stricter emissions standards as well as weight restrictions that support greater fuel efficiency.

Pelton runners on the Gilkes shop floor

Gilbert Gilkes & Gordon Ltd. — commonly referred to as Gilkes — is a leading manufacturer serving both the power generation and engine industries. Gilkes Hydro is a global leader in hydropower systems that generate electricity from water, with more than 6,700 turbines installed in more than 80 countries. Gilkes Pumping Systems manufactures a range of sophisticated pumps for the cooling of high-horsepower diesel engines, supplying many of the world's top diesel engine manufacturers.

Founded in the United Kingdom's Lake District in 1853, Gilkes is steeped in tradition. Its main factory has been in the same location since 1856, and it has been under the same basic ownership since 1881. With a loyal customer base and a stable of proven product designs, Gilkes was able to lead the global market in small hydropower systems and engine cooling pumps for many years.

"The traditional approach at Gilkes was to create a high-performing design through testing, optimize it for production in our factory, then rely on variations of that design for years," said Lindsey Entwistle, mechanical design engineer for cooling pumps at Gilkes. "Customers were very happy with the product's performance, and it was an approach that worked for many years."

ANSYS CFD simulation of a Pelton turbine runner

However, in the last decade, the landscape began to change in both industries Gilkes served. Due in part to government subsidies for renewable energy, the market for hydro-turbines began to grow quickly in many regions of the world, new competitors appeared, and Gilkes had to guarantee higher turbine performance to retain its market share.

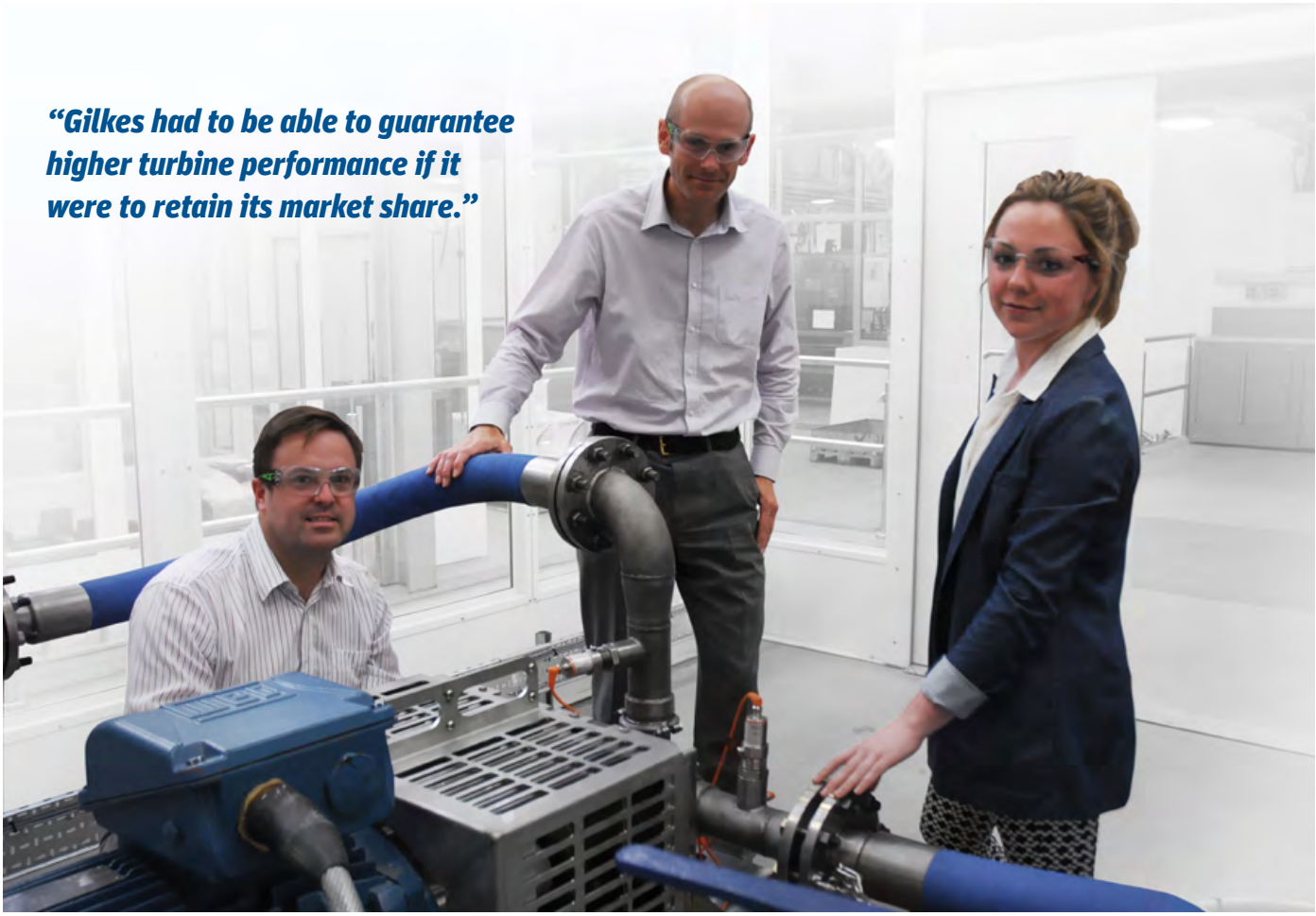
In addition, increasing environmental awareness meant new regulatory standards for diesel engines. Gilkes' existing pump designs required higher levels of performance to contribute to decreased emissions and other environmental goals, as well as reduced production costs. For the first time in years, Gilkes' product requirements were dramatically changing.

Simulation: A Competitive Advantage

Across both market segments, Gilkes' historic competitors moved quickly to develop innovative designs that capitalized on these opportunities, relying heavily on computational fluid dynamics (CFD) engineering simulation tools to drive fast design and market launch of new products that answered these needs.

Engineering simulation was not a new concept to Gilkes. Historically, when design analysis was needed, the company had outsourced CFD simulation to experienced consultants. Gilkes had also sponsored the work of a Ph.D. student, at nearby Lancaster University, who had built his thesis around answering one of Gilkes' pressing engineering challenges.

Gilkes has a long history of engineering excellence.



"Gilkes had to be able to guarantee higher turbine performance if it were to retain its market share."

Gilkes cooling pumps on the shop floor (left) and ANSYS structural simulation of a dual-circuit marine pump (right)

GILKES

Gilkes at a Glance

- → 2014 revenues: £39.6 m
- → Number of employees: 239
- → Headquarters: Kendal, Cumbria, United Kingdom

"We had dabbled in engineering simulation in the past, but not really committed to it as a central strategy to support our product innovation," explained Alan Robinson, research and development manager for Gilkes hydro-turbines. "We have a history of under-promising and over-delivering, but, with efficiency guarantees so heavily weighted in bid evaluations, we knew we had to improve our product performance. We had to innovate so we could offer higher guarantees and keep our valued ethos. The engineering team responded with a proposal to create an in-house simulation capability — because we recognized that simulation had become a key competitive edge we were lacking.

"We showed the board of directors the capabilities of simulation software and how it could help us quickly redesign our products," Robinson continued. "The board agreed to make a significant investment in not only technology but in new engineering staff with simulation skills."

A New Capability Takes Shape

In 2013, Jo Scott was hired as an experienced CFD engineer for Gilkes' hydro-turbines business. Because Scott had used simulation software for 20 years in his previous positions, he became the champion of simulation within both Gilkes business units.

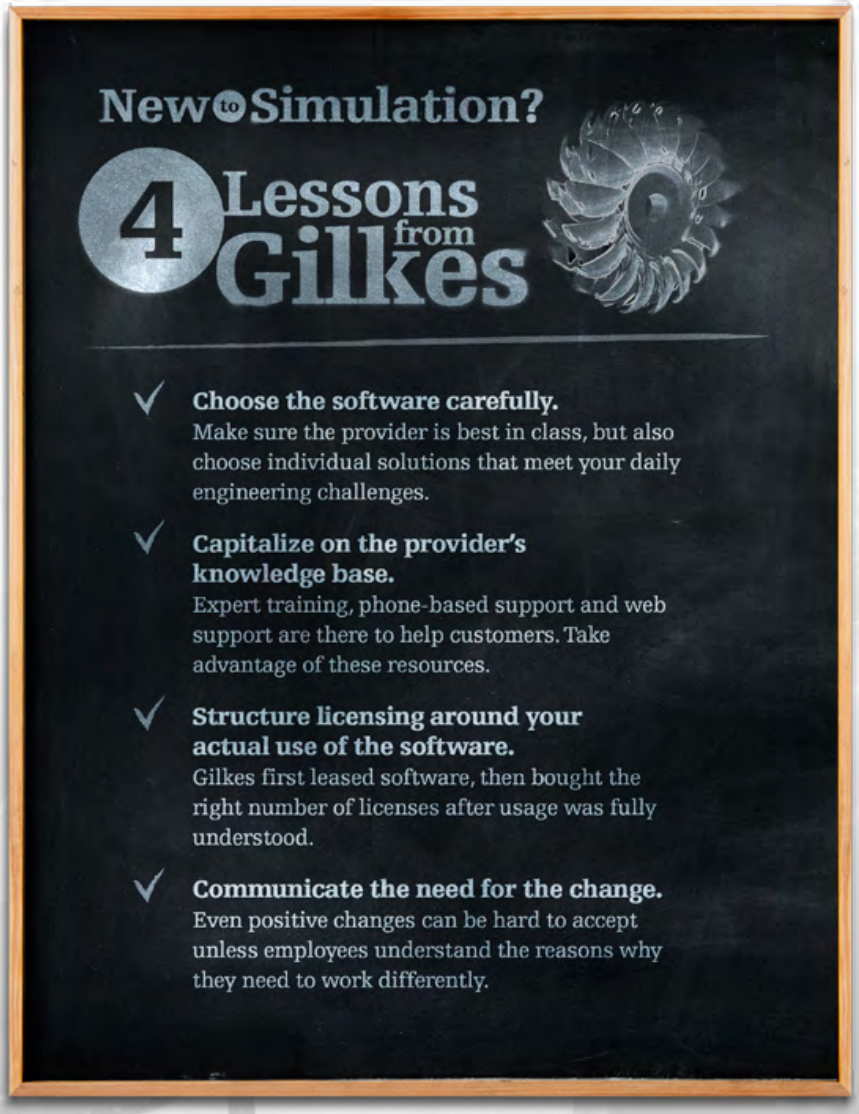
"Our first lesson was to choose the software carefully," noted Scott. "Even after we decided to purchase a best-of-breed software, we had to select the actual solutions. We realized that CFD simulation was a requirement for both businesses, but that the pumps engineering team also needed to do finite element analysis (FEA) to ensure structural robustness. There were many levels of FEA analysis tools, so we had to match the solution to our day-to-day challenges."

While Scott initially tried to train some of his colleagues in simulation software, he quickly realized that the best strategy was to

leverage the expert training provided by ANSYS. "Even though I knew the CFD software very well, it simply wasn't time- and cost-efficient to have me manage the internal training — and I had little working knowledge of FEA solutions," said Scott. "So we had a team of people attend formal software training, which helped us get a core group of users up and running."

Today, Scott is joined by three part-time ANSYS users in the hydro-turbines business. In the cooling pumps business, Gilkes has four engineers using CFD software and another three team members using finite element analysis software to analyze structural issues.

Throughout, Gilkes has made full use of phone-based support and an online customer portal to get answers to technical questions. "Software providers offer web- and phone-based support for a reason — and you shouldn't be shy about using those resources," stated Scott. "There's so much product knowledge there."



While Gilkes began with a single seat of software — relying on a leasing approach for additional seats — in 2015, the company realized that it needed to make a longer-term commitment. "Once we were able to assess the real usage of simulation software at Gilkes, we saw that it made more sense to buy licenses instead of leasing them," said Scott. "It was a financial decision based on how frequently simulation was being used by our team by 2015."

A Welcome Change

At Gilkes, the adoption of engineering simulation was embraced by many existing employees who were eager to learn leading-edge skills. "Our engineers had been doing a lot of complex calculations and design work using more-traditional methods, so they were extremely enthusiastic about having new software do the work for them," said Robinson. "They wanted to get up to speed on the latest practices."

The new focus on simulation is also attractive to recent graduates who are ready to apply the skills they have learned in college. "Traditionally, there was a gap between how Gilkes engineers were working and the way new engineers were being trained at university," noted Entwistle, who joined Gilkes in 2014. "But that gap was disappearing by the time I arrived. And today, Gilkes really is at the forefront of engineering practices. It's exciting to work here."

"We showed the board of directors the capabilities of simulation software and how it could help us quickly redesign our products The board agreed to make a significant investment."

While the change was welcome, Robinson noted that it was challenging from a cultural standpoint. "Previously, we had engineers spreading their skills thinly to oversee entire projects," he explained. "Now we've installed a modular process in which people have different roles and different areas of expertise. We have specialists at every stage, including our CFD and FEA experts. We've had to change our process and re-align employees' roles, but that was necessary to fully adopt simulation as a core competency.

"It was helpful that everyone recognized the need to change," added Robinson. "We realized that our efficiencies had to improve, and a lost order helped everyone recognize that we had to do things differently. I would advise other businesses to share the top-level vision with their engineers, because that certainly helped us overcome any cultural resistance at Gilkes."

Launching a New Era

In just three short years, Gilkes has transformed from having no internal simulation capability to having 10 engineers regularly using simulation software. The company has invested approximately £150,000 in building this capability — including software licensing, hardware and training. The company is now looking into the creation of a high-performance computing (HPC) cluster to manage large simulations and make its analysis capabilities even more powerful.

"Engineering simulation now forms the basis of a strategy of analysis that is being used to promote intelligent, blue-sky design thinking, where we continually assess and develop our designs," said Robinson.

"It's hard to measure the financial impact of our investment in simulation," he continued. "But I can tell you that we are now seeing a return on that investment due to winning more contracts because we can produce innovative designs more quickly and cost-effectively. We believe that simulation has made a real difference already — and that it's positioning Gilkes for a new era of success."

Gilkes cooling pumps

"We have won some sizable customer contracts because we can produce innovative designs more quickly and cost-effectively."

THE NEW SPACE RACE

Thomas Markusic founded Firefly Space Systems, Inc., in 2014, for one simple reason: to make space more accessible. The former SpaceX engineer is using next-generation rocket technologies and leading-edge engineering practices to move Firefly toward the mass production of affordable launch systems for small satellites. Its goal is to get these launch systems to market quickly, using the simplest and most cost-effective technologies available. While few companies are rewriting the rules of their industry to the same degree as Firefly, this company has valuable lessons for every organization that's seeking to increasingly invigorate development efforts.

DIMENSIONS: You often use the term "new space" when describing Firefly's mission. What does "new space" mean to you?

THOMAS MARKUSIC: The "old space" paradigm was based on government control of space access, a culture characterized by bureaucracy and rules, and relatively slow, methodological progress. By contrast, "new space" is about picking up where the pioneers of the 1950s and the 1960s left off. It's about having a bold vision of providing high-speed space transport for civilians, creating re-usable vehicles that can orbit the Earth, and eventually colonizing other planets. Firefly wants to democratize space by dramatically lowering the cost of access and dramatically increasing spaceflight opportunities for more people. By privatizing the space industry, we want to subvert the dominant big aerospace paradigm of slow progress and high costs. As a new space company, we are shifting to mass production methods, rapid application of real-world lessons, and ubiquitous use of advanced design tools, such as simulation, that can help us move quickly.

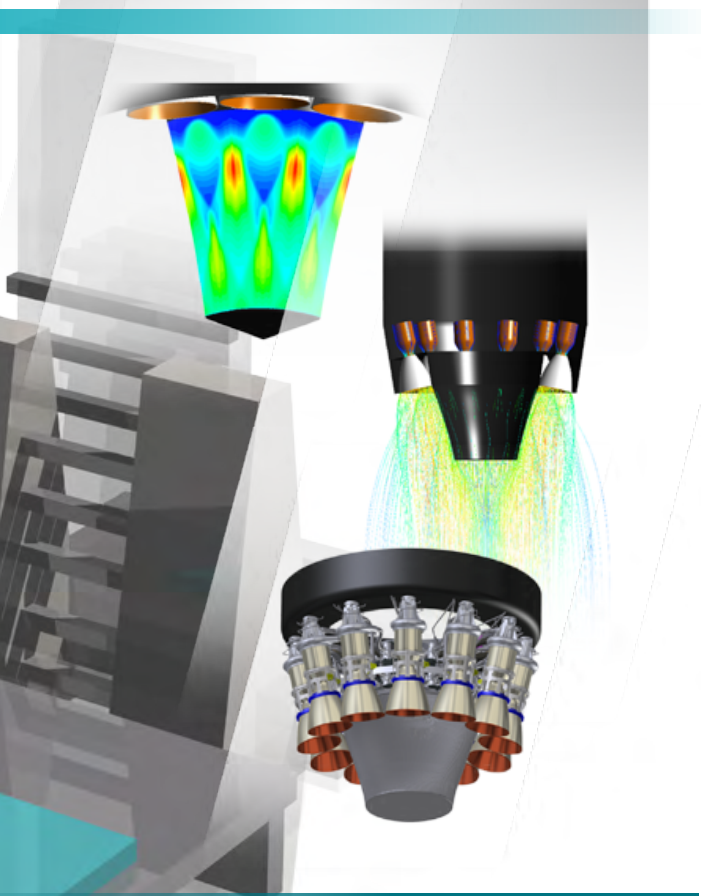
Firefly Beta represents the second vehicle in a scalable family of launchers specifically designed to address the needs of the light satellite.

D: Firefly was founded on the tenets of innovation and disruption. How are those ideas reflected in your business model, your culture and your engineering team?

TM: First of all, we chose to base our operations in Austin, Texas, specifically to remove ourselves from the traditional "old space" business model. We're a new kind of company, with new partnerships, new ideas and new ways of working. If you raise your eyebrows when you hear we're headquartered in Austin, that's the reaction we're looking for.

SIMULATION AT FIREFLY

Firefly's first-stage aerospike engine utilizes a cluster of 12 conventional rockets. ANSYS CFD software is used to understand the complex 3-D flow field that evolves as the plumes from the 12 engines merge and to help reduce temperatures by an order of magnitude.



"Firefly wants to democratize space by dramatically lowering the cost of access and dramatically increasing spaceflight opportunities for more people."

Furthermore, Firefly has rejected many traditional job titles and personnel hierarchies. We've created a flattened organization in which ranks and organizational boundaries are inconspicuous, where people truly feel that they are part of one organization with a singular mission for success. We've deliberately fostered a communication infrastructure in which every person in the organization is able to clearly see, and is able to articulate, how his or her work contributes to the profitability and success of the company as a whole.

Finally, we've worked hard to create a very diverse team at Firefly. We have senior engineers from the traditional space industry working beside recent college graduates. Why is this important? Because diversity produces a wide range of human capital, ideas, strengths and leadership styles that result in innovation. As of mid-2015, 12 percent of our engineers are women, which I would guess is a fairly high percentage for an aerospace company — and a statistic that Maureen Gannon, our vice president of Business Development, takes great pride in. She is a huge champion of diversity within our business. (See sidebar, "STEM: Not a Man's World.")

D: Can you tell us more about how you have flattened the engineering function in particular?

TM: In the engineering organization, we are deliberately working to eliminate job titles such as analyst, drafter, etc. We firmly believe that, given today's integrated design tools environments, the same engineer who is designing the part can easily generate a physical definition of the part, in addition to performing part-level and system-level finite element analysis (FEA) and computational fluid dynamics (CFD) simulation. This is not always easy because many people tend to get very comfortable with one task. However, we challenge our engineers to be accountable for their products as part of a system — and ensure that they deeply understand their product's cradle-to-grave requirements, functionality, manufacturability and operability.

D: How has your disruptive philosophy influenced your engineering team's use of technology?

TM: When making product design decisions, we perform a series of multidisciplined, collaborative trade studies and analyses before we choose a design path. Our selection of IT and software tools is no different. We did not start Firefly with one single software in mind. We have initiated a number of parallel studies utilizing various computer-aided design, computer-aided manufacturing, FEA, CFD, integrated design environment and software development kit solutions to select the ones that best suit our company and vision. We have been proactive in implementing configuration resources, product life-cycle and enterprise resource-management tools in addition to our technical software tool sets — even at the company's early stage when we have a relatively small team and only one product. We are designing our IT from the ground up and with purpose, before it gets too complicated and forces us to choose a suboptimum system for our company.

STEM: NOT A MAN'S WORLD

Maureen Gannon loves her position as vice president of Business Development for Firefly Space Systems, Inc. She embraces working with the company's engineers and crafting business solutions to match their plans of filling the sky with satellites launched by the company. On occasion, however, she reflects on her own educational and career path — and has often wondered why she didn't become an engineer herself.

"I was always passionate about science and engineering but, as a young girl, I was not encouraged in school to pursue those areas either as a field of study or a future profession," recalled Gannon. "At the time, I felt it was not an option available to me."

After earning a B.A. in international relations and an M.A. in international management, Gannon began her career in technology companies both in the U.S. and abroad — and quickly realized that most engineers she interfaced with were men. She eventually decided to pursue her engineering goals and enrolled at the University of California at Berkeley to gain some technical background. Again, she looked around and found herself surrounded by men. "It started to dawn on me that perhaps I was not the only young girl who had been interested in science and engineering, but had not been encouraged or felt comfortable to explore it as a career," said Gannon.

Today, helping girls and young women pursue careers in science, technology, engineering and math (STEM) is a personal passion for Gannon. As a client of Virgin Galactic in 2009, she pitched and cofounded its now nonprofit foundation called Galactic Unite. She personally raised more than a million dollars to fund the group's first of many STEM scholarships for women. Through funding, education and outreach, Galactic Unite continues to offer the encouragement and support that young people need to pursue careers in STEM disciplines.

In addition to her role as VP of Business Development at Firefly, Gannon strives to continue making a difference in STEM education. She has begun by forming new partnerships with local universities, high schools and even elementary schools to spread the word about engineering and other STEM-related careers and continues to build Firefly's internship program. "We work to attract not just young women, but students of all genders, ethnicities and backgrounds, to careers in science," noted Gannon. "Firefly was founded to break new ground in the aerospace industry — and that means bringing in new thinkers with many different perspectives. The more diversity in our company and our industry, the more diverse our ideas will be. That increases our chances of driving true innovation."

"We work to attract not just young women, but students of all genders, ethnicities and backgrounds, to careers in science."

D: Since the space industry is heavily regulated, how are you cutting time and costs out of the standard approval process — which must be lengthy and complicated?

TM: The space industry is heavily regulated for practical reasons. Even if you're launching a rocket from a remote location such as the middle of the ocean, that launch requires careful planning, since various propulsive stages of the rocket inevitably cross habitable areas during ascent. As a U.S. company, Firefly is governed by Federal Aviation Administration laws and regulations, regardless of our launch locations around the globe. The process of acquiring a launch license requires involving many governmental and commercial entities. There are human and property safety considerations. There are also environmental impact considerations that require careful engineering analyses.

To navigate these approvals as quickly as possible, Firefly needs to have the ability to completely simulate and execute a launch from ground to orbit — considering a number of predictable and unpredictable boundary conditions such as weather, pressure, electromagnetic and electrostatic conditions, and even solar storms. Other design, analysis and simulation activities at Firefly focus on calculating instantaneous impact points in case of an errant flight. The possibility of terminating a flight requires many worst-case analyses and computationally intensive simulations.

While the traditional methods for mitigating launch failures involve a large footprint of resources and manpower, Firefly is leveraging engineering simulation to design and verify a new generation of built-in safety assurance mechanisms for our first rocket — and it will meet the strictest government standards. By demonstrating that our technology works, simulation is helping us to obtain regulatory approvals and get to space faster.

D: Firefly is not only seeking to democratize space by cutting costs, but to create greener, more-sustainable technologies. How do your engineers balance these priorities, which are typically at odds with each other?

TM: Lower-cost, green, well-designed and well-functioning are not mutually exclusive requirements. When science, engineering and the laws of nature are harmonized, surprisingly, things work better. You can see this all around you, in better modern buildings, bridges, roads, clean energy and even high-performance cars. For example, it is inevitable that cars of the future, regardless of the source of energy, will utilize electric motors as the propulsive force. It's just meant to be that way. Electric motors are rotating machines. They utilize some of the most elegant laws of nature, such as electromagnetism, in the right form and in a functional way. They produce force and motion at greater than 90 percent efficiency. For over 100 years, we have invested our engineering R&D talents into perfecting the reciprocating internal combustion heat engine. Imagine what could be possible if that same amount of engineering resources could be expended toward more-refined products that are better harmonized with nature, rather than working against it.

At Firefly, we're adopting a similar philosophy. We're looking at every possible option to take advantage of physical and natural laws to make our rockets better, simpler, more efficient, more affordable and, yes, greener. Our rockets utilize technologies that maximize energy transfer and provide a "simpler, sooner" product for accessing space.

D: Few companies are able to revolutionize an industry like Firefly. What's unique about the DNA of these companies?

TM: I believe that all disruptive companies are problem-solvers. They create products, services and tools that address societal and global challenges, sometimes in an unexpected way. And everyone from the CEO down must be passionate and focused on solving that problem.

At Firefly, engineers are the people actually applying the physical sciences to solve the technological problems related to reaching space. But every technology company should have executives at the helm who have a deep appreciation for engineering and an understanding of what the engineers are trying to accomplish, in addition to thinking about their company's fiscal and fiduciary responsibility to shareholders. Because Firefly is aiming for a highly technical goal, its executives must think well beyond "discounted cash flow" and "net present value." Understanding the very nature of producing hardware that imparts greater than 100,000 foot pounds (ft-lb) to escape Earth's gravity requires different management challenges than, say, writing an app.

Revolutionary companies are also ambitious, hard-working and dedicated to achieving results quickly. As an engineer myself, I'm incredibly impressed with the pace of progress accomplished by the Firefly development team. It is the most productive team that I have worked with, and they have a lot of fun getting stuff done.

We've got a good thing going. Within just 20 months of operation, we will have built world-class facilities and run rocket engine tests using designs completely developed in-house. Nothing drives a technical team to success like a clear vision of an important goal.

Firefly Space Systems

- **Founded: January 2014**
- **Number of employees: 55+**

Prior to founding Firefly Space Systems, Inc., Thomas Markusic served in a variety of technical and leadership roles in new-space companies: vice president of Propulsion at Virgin Galactic, senior systems engineer at Blue Origin, director of the Texas Test Site, and principle propulsion engineer at SpaceX. Prior to his new-space work, Markusic worked at NASA and the USAF as a research scientist and propulsion engineer. He holds a Ph.D. in mechanical and aerospace engineering from Princeton University.

INNOVATIVE AT HEART

With its groundbreaking stent design, Cardiatis is poised to change the lives of cardiac patients worldwide. But this Belgian company is also changing the way employees at all levels of the organization use specialized technology that is traditionally associated with product-development engineering.

By Noureddine Frid, Chief Executive Officer, Cardiatis, Isnes, Belgium

Cardiatis is accustomed to doing things differently. Even though the medical community has been using the same basic stent design to treat aneurysms for decades, traditional devices have obvious drawbacks — including a lack of permeability that interferes with normal blood flows and tissue regeneration in the area of the aneurysm. Since 2002, Cardiatis has focused on developing a better solution.

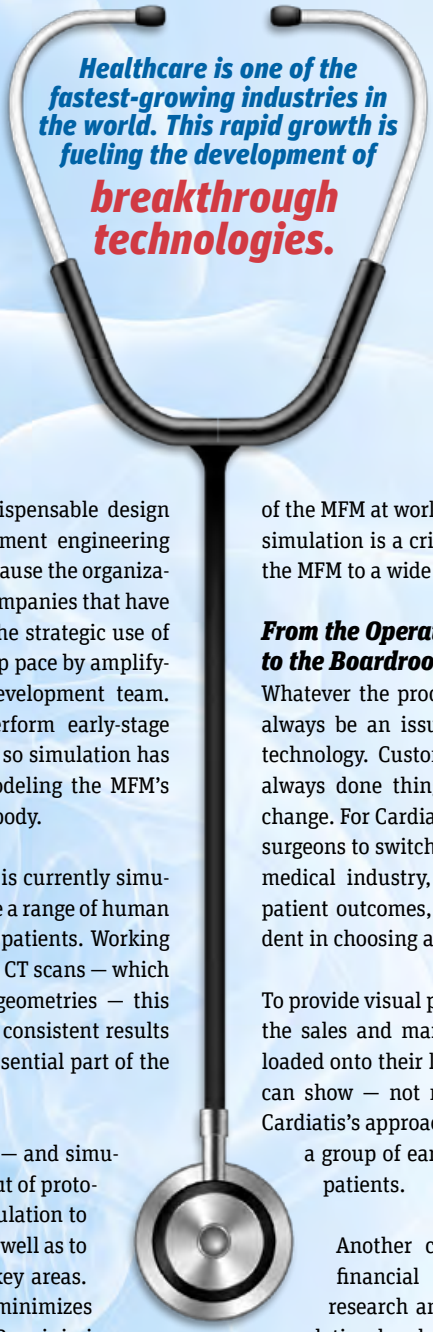
The company's product, the Multilayer Flow Modulator (MFM®), represents a paradigm shift in the treatment of aortic aneurysms. Composed of layers of a braided cobalt alloy that form a mesh, the MFM is porous. It enables the turbulent blood flow that characterizes traditional stents to become more uniform, reducing shear wall stress and supporting healing of damaged tissue.

Cardiatis focuses on making this technology available to patients around the world as quickly as possible, because time is critical after an aneurysm is detected. Without timely surgical intervention, aortic aneurysms can rupture — and they kill approximately 15,000 people each year in the United States alone. Because Cardiatis is confident that the MFM represents the best possible treatment for aortic aneurysms, company employees are dedicated to getting this product launched into the global marketplace in a rapid manner.

However, as with any groundbreaking technology, there are significant barriers to bringing the MFM to market. Since Cardiatis is a small startup company, it needs to attract investors to support continued optimization of the MFM. To win customers, the product's actual users — in this case, cardiovascular surgeons — must be convinced of the benefits of the MFM over traditional stent designs.

Because the MFM is a medical product, exhaustive product testing must be conducted to ensure that the device is safe and effective. Government agencies around the world must grant regulatory approvals, and insurance companies need to formally certify the effectiveness of the MFM before they offer patients financial coverage.

In keeping with its focus on innovation, Cardiatis has identified a reliable solution for addressing every one of these needs: engineering simulation.



Healthcare is one of the fastest-growing industries in the world. This rapid growth is fueling the development of breakthrough technologies.

Simulation has been an indispensable design tool for the product development engineering team at Cardiatis for years. Because the organization is competing with larger companies that have greater engineering resources, the strategic use of simulation helps Cardiatis to keep pace by amplifying the efforts of its product development team. Obviously, it is unfeasible to perform early-stage product testing on human patients, so simulation has been a foundational solution in modeling the MFM's performance inside a virtual human body.

At Cardiatis, a team of Ph.D. engineers is currently simulating the performance of the MFM inside a range of human anatomies that represent actual cardiac patients. Working with a database of 4,000 two-dimensional CT scans — which are transformed into three-dimensional geometries — this team is ensuring that the MFM will deliver consistent results for all patients. This ongoing effort is an essential part of the company's product development efforts.

Of course, physical testing is also required — and simulation is helping to drive significant costs out of prototyping at Cardiatis. Engineers leverage simulation to pre-select the best product configuration as well as to optimize the physical testing to focus on key areas. This intelligent approach to prototyping minimizes the use of expensive cobalt alloy material. By minimizing material waste, Cardiatis estimates that simulation reduces the cost of physical testing by about 10 percent.

However, engineers are not the only people at Cardiatis who rely on simulation — or who use powerful simulation images of the MFM at work inside virtual human bodies. At Cardiatis, simulation is a critical tool for demonstrating and validating the MFM to a wide range of audiences.

From the Operating Room to the Boardroom

Whatever the product or industry, resistance to change will always be an issue when introducing a revolutionary new technology. Customers like to maintain the way they have always done things — and they are naturally resistant to change. For Cardiatis, the key challenge is convincing cardiac surgeons to switch to an entirely new stent technology. In the medical industry, making even a small change can affect patient outcomes, so physicians need to be extremely confident in choosing a new solution.

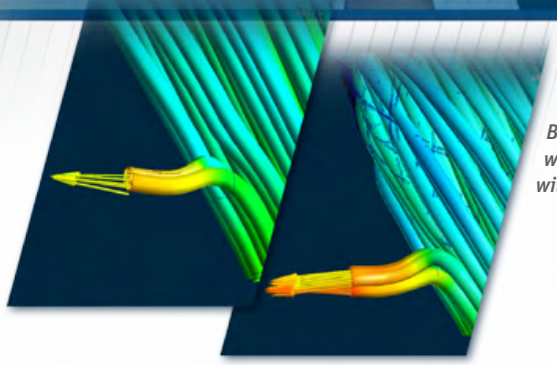
To provide visual proof of MFM's superiority, every member of the sales and marketing team at Cardiatis has simulations loaded onto their laptops. When meeting with surgeons, they can show — not merely describe — the real advantages of Cardiatis's approach. This has been a powerful tool in helping a group of early adopters begin using the MFM in actual patients.

Another challenge for Cardiatis lies in attracting financial investors who will fund its intensive research and development efforts. Engineering simulation has been equally effective in demonstrating the MFM technology to venture capital firms. Simulation takes a theoretical idea and makes it visual and easy to understand. Even people who don't have a medical background respond enthusiastically when they see Cardiatis's unique stent design in action.

Because the MFM is composed of a permeable metal mesh, it supports robust blood flows.

It is essential that the
healthcare industry begins to adopt new tools and processes.

Because the MFM could represent the best-possible treatment for aortic aneurysms, Cardiatis employees are dedicated to getting this product launched into the global marketplace in a rapid manner.



Blood flow simulation without MFM (left) and with MFM (right)

Securing Critical Approvals

The Cardiatis MFM is in use today in Europe and South America to treat high-risk patients who are unable to benefit from traditional stents. Before providing coverage for these patients, insurance companies request proof of the likely results from the MFM — and this proof is submitted in the form of patient-specific simulations.

The engineering team at Cardiatis generates simulations that are based on the actual patient's scans and images, then provides these simulations to the medical team and health insurer. In these high-risk cases, the patient's physical geometry is often very complex, with multiple aneurysms or severely compromised blood flows.

Cardiatis has been pleased with the ability of simulation to represent these complex geometries quickly and accurately. And, for those patients relying on the MFM for a year or two, simulation has proven remarkably accurate in predicting how the MFM would perform.

Insurance companies have also been impressed with the results achieved from simulation. In some markets, including Brazil, insurance claims are not covered unless a simulation has been submitted in advance of the surgical procedure.

In other parts of the world, including the United States, Cardiatis is still securing regulatory approvals for the MFM. This is a complicated process that is supported by simulation. For example, in the U.S., the MFM is considered a Class 3 device, which means it has no "predicate," or pre-existing competitor. The approval process for Class 3 devices is long and complicated — typically around 50 months.

Engineering simulation is proving to be very helpful in submitting proof of concept. While clinical trials are still a prerequisite to regulatory approval, simulation is helping to get to that stage faster by providing early-stage validation that the technology actually works.

Cardiatis

Cardiatis at a Glance

- *Number of employees: 41*
- *Headquarters: Isnes, Belgium*
- *Industry: Healthcare*

Taking the Pulse of the Future

More than most companies, Cardiatis has democratized engineering simulation by placing it in the hands of virtually every professional — from top-level executives to sales reps. Demonstrating the real-world benefits of MFM technology via fluid-flow simulations has become a way of life within the company.

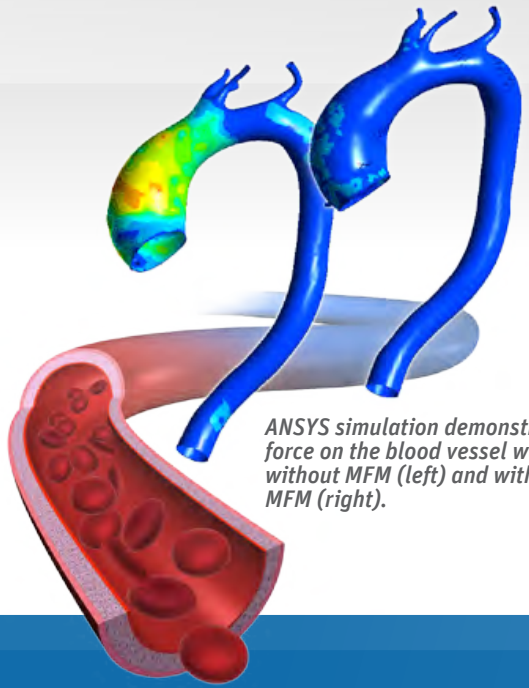
But Cardiatis is just getting started in re-imagining how simulation might be used outside the engineering function. Cardiatis envisions a day when surgeons will have tablet computers loaded with a consumer-level version of simulation software. In assessing an aneurysm patient, a doctor could input two-dimensional scans such as CTs or MRIs, then see immediately how that specific patient might benefit from the MFM. The physician could then submit the simulation images electronically to both the surgical team and the patient's insurance provider.

As the global population ages and life expectancy increases, healthcare is one of the fastest-growing industries in the world. This rapid growth is fueling the development of breakthrough technologies, like the MFM, that propose new solutions to common health issues.

To get these innovations to market quickly so patients can begin benefiting from them, it is essential that the healthcare industry begins to adopt new tools and processes. Cardiatis believes that simulation — once the domain of engineers — offers a number of advantages, especially as other healthcare businesses seek to validate their products to doctors, investors, regulators, insurers and other key audiences. Beyond its use in the medical field, simulation is a powerful tool for any company looking for an innovative, flexible means to demonstrate its products.

About the Author

Trained as an engineer in industrial chemistry, Noureddine Frid started his career at Corvita, focusing on developing vascular prostheses for surgery. He also worked on first-generation covered aortic stents — aneurysmal excluders with no need for open surgery. This innovative technique was designed for patients who could not undergo classic open surgery to treat their aneurysms. While working at Medicorp R&D Benelux S.A., he successfully developed a new stent design for the treatment of carotid stenosis, composed of a shape-memory material that would become rigid at human body temperature. This device, Expander®, is now implanted in thousands of patients worldwide. In 2002, he founded Cardiatis to develop a new concept: 3-D stents composed of several interconnected layers. Frid is the owner of 20 patents for his technology innovations.



ANSYS simulation demonstrates force on the blood vessel walls without MFM (left) and with MFM (right).

5 DIMENSIONS OF SIMULATION

- **Reduce Cost:** Reduce cost of physical testing by about 10%
- **Enable Sales:** Show, not tell, product benefits
- **Attract Investors:** Demonstrate product technology to venture capitalists
- **Provide Insurance Evidence:** Provide proof of treatment effectiveness to obtain patient funding
- **Secure Regulatory Approval:** Deliver early-stage validation of product technology to streamline approval process

SMART GOALS FOR A SMARTPHONE CHIPSET DESIGN TEAM

In Qualcomm's Smartphone Chipset Design Team, the five letters "PPATS" play a critical role in product development.

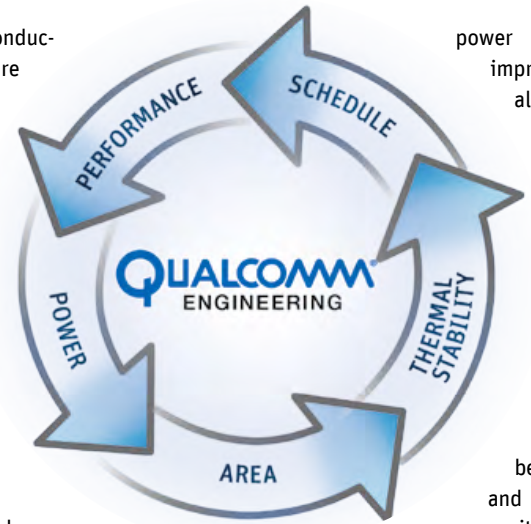
By Venugopal Puvvada, *Vice President of Engineering, Bangalore Design Center, Qualcomm, Bangalore, India*

The conventional wisdom in industry is that engineering teams should focus on innovation — while also honoring the three goals of consistently improving product quality, decreasing time to market and maximizing cost efficiency.

While there's no arguing that these goals are critical, as guiding principles they fall short because they are too vague. They fail to recognize the real differences among engineering teams, which serve a diversity of customers with specific needs. To secure and maintain market leadership, every product development team must define its own set of priorities — based on what is truly valued by the customers who buy its products as well as the end consumers who use them every day.

Qualcomm has built a 30-year history of success by understanding, addressing and often anticipating the changing needs of the global market for wireless telecommunications products and services. Billions, maybe trillions, of times a day, consumers around the world touch something made better by Qualcomm — from the smartphones in their pockets and the tablets on their coffee tables to wireless modems in their briefcases or navigation systems in their cars.

In designing the company's core semiconductor products, Qualcomm's engineers are guided by a SMART (specific, measurable, attainable, realistic, timely) goal that summarizes the concerns of consumer electronics manufacturers, automakers and other customers that incorporate Qualcomm's technologies into their products. PPATS stands for power, performance, area, thermal stability and schedule. Each of these tenets plays a central role in making Qualcomm the world leader in semiconductor technology.



- **Power.** Anyone who owns a mobile phone knows the frustration of seeing a low-battery warning. Chips from Qualcomm support the development of next-generation power systems that decrease energy consumption demands and answer end-consumer needs. Qualcomm employs physics-based simulation to design energy-efficient integrated circuits (ICs) that meet stringent customer requirements for power and reliability. Because power improvement is a priority for customers, all of Qualcomm's engineering efforts consider and address power consumption.

- **Performance.** As cell phones, tablets and other devices become the hub for multiple activities — from social media and shopping to gaming and video streaming — consumers require faster, more reliable performance. Qualcomm's chips must be designed for maximum robustness and uninterrupted connectivity to keep pace with growing user needs. Qualcomm's Snapdragon processors, for example, deliver industry-leading performance in many smartphones. Qualcomm's chips deliver uninterrupted connectivity via the latest communication standards, such as 4G LTE. To deliver this, Qualcomm engineers perform rigorous simulations.

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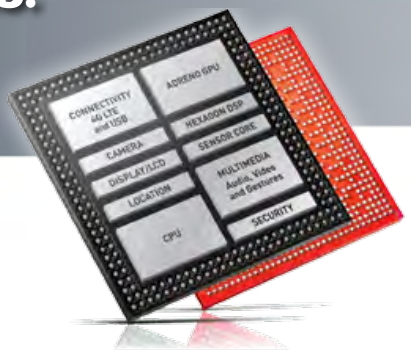

- **Area.** Consumers demand more and more functionality, but in a smaller product package. Qualcomm's chips need to be precisely engineered to squeeze as much functionality onto the available area without adding weight or materials. Engineering simulation enables Qualcomm engineers to optimize the silicon chips to deliver maximum performance with the fewest transistors and lowest power consumption levels. This is a challenge that guides Qualcomm engineers every day.

- **Thermal stability.** With so much electronic activity occurring inside today's consumer products, heat buildup is an ongoing concern that not only affects product performance but represents a safety issue. When electronic circuits run hot, their performance degrades. For this reason, Qualcomm utilizes sophisticated physics-based simulation to ensure that device temperatures are managed appropriately. Simulation helps Qualcomm engineers to identify areas of concern early in the product development process, long before products are released to manufacturers and consumers.

- **Schedule.** Qualcomm operates in unarguably the fastest-moving industry in the world today. As manufacturers of mobile phones and other devices compete to launch the latest and greatest product, Qualcomm is often under pressure to supply innovative chip technologies very rapidly. However, the engineering team can't just focus blindly on speed; it also has to ensure the high reliability needed to earn customer trust. Qualcomm's product development team has created a system of warnings and triggers to ensure that aggressive milestones are achieved dependably, every single time.

PPATS reminds Qualcomm engineers that in today's complex global markets, it's not enough to focus on the traditional, vague tenets of quality/speed/cost. Engineers have to go deeper, asking questions such as, How do my customers define quality? What features really matter in the marketplace right now? How quickly are my products actually needed? What is my customer's real cost threshold?

Because Qualcomm operates in the high-profile consumer electronics marketplace, it's relatively easy for the company's engineers to recognize their priorities. After all, the daily headlines are filled with successful launches of mobile phones and other consumer electronic products as well as market studies and surveys showing end-user needs for longer battery life, enhanced connectivity and other product characteristics.

As a best practice, every engineering team should step back from the detailed requirements of individual customers that guide its everyday work and distill these needs into a few core tenets.

Venugopal Puvvada has been vice president, Engineering, Qualcomm Bangalore Design Center, for the past eight years. Currently, he is responsible for the Customer Enablement and Technology Group. Puvvada has more than two decades of experience. He worked at Texas Instruments Bangalore for 13 years prior to joining Qualcomm.