SUMMER 2016

DIMENSIONS

SIMULATING BUSINESS SUCCESS

Teamwork Drives Red Bull Racing

Red Bull Racing Formula One Team | ANSYS Innovation Partner

Intel
Managing the Flood of Data

Mobiveil
Business Potential of the IoT

QuickLogic
The Sensor Revolution

ANSYS

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Editorial Advisers
Robert Harwood
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Gregg Weber
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Contact *Dimensions* at
ansys-advantage@ansys.com

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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.

PRODUCT DESIGN CHALLENGES DRIVE SIMULATION EVOLUTION

By Jim Cashman, CEO, ANSYS

Around the year 2000, some experts believed that the market for engineering simulation software had leveled out. However, ANSYS leaders saw almost infinite opportunities for growth. By meeting the needs of product developers, ANSYS stayed just ahead of new product design requirements and delivered essential simulation software. Sixteen years and many software advances later, the company still believes in endless possibilities to help customers develop better products through simulation.

There is some dispute about who said it first, but the great Danish physicist Neils Bohr is often credited with having said "It is very difficult to predict — especially the future." Even some of the most brilliant, respected pioneers in their fields have had difficulty making predictions. Like Thomas Watson, president of IBM, who said in 1943, "I think there is a world market for maybe five computers." Or Ken Olsen, founder of Digital Equipment Corporation, who made this statement in 1977: "There is no reason anyone would want a computer in their home." These were tough calls based on sound reasoning at the time. To be fair, we all make mistakes, and we shouldn't be too hard on these stellar businessmen.

About 20 years ago, the engineering simulation industry — which uses software to make models of new products whose properties and performance can be tested on a computer, eliminating the need to build and test physical prototypes — experienced a similar period of doubt. Some industry leaders believed that the market had plateaued. They had some solid reasons for believing this: Performing simulation was difficult, generally requiring an engineer with a Ph.D. and a good grasp of the complex mathematics involved, along with enough expensive computing power — and time — to solve complex product design challenges. The limited supply of such high-level engineers and the relatively slow computers of the time led them to believe that engineering simulation had peaked.

Our Contrarian Viewpoint

At ANSYS, we did not share this outlook. In fact, we believed the market had tremendous room for growth. How could you talk about stagnation when only about 1 in 30 engineers used simulation at all? From decades of continual improvements, engineering simulation software was increasingly proving its worth by reducing product development times and costs, enabling companies to get their new products to market faster. It also increased their confidence that the product would work as specified the first time and every time throughout its expected lifecycle. Finally, engineering simulation was moving in the direction of creating a virtual prototype of the complete product, not just each component of the product in isolation. The physical, electrical and thermal interactions of various components when put together in a final product play a large role in determining how the product will function in the real world. To create a virtual prototype of a complete product, you have to be able to simulate ALL of it. As you'll see below, this factor drove ANSYS to add electronics (and soon other physics) simulation to our offerings; it also gave rise to the concept of considering embedded software an integral component of a product, not simply some control code added as an afterthought. Engineers became convinced that embedded software could be subject to modeling, simulation, verification and certification as much as any physical component of a product.

Our attitude at ANSYS reflected these positive trends and driving forces. We believed that every engineer could benefit from simulation — not just the Ph.D.s, but any engineer involved in product development. After all, simulation is basically the automated solution of the equations they learned during their engineering studies. We just had to continually make setting up and running these automated simulations easier so that it was accessible to every engineer. So we started on a journey that continues to this day to simplify simulation. To do this, we have relied on experts in the field to let us know what is coming so we can strike out a little bit ahead of the pack. It's like surfing. You want to stay just a little bit ahead of the wave. If you're way ahead of it, you will miss the ride (in technical terms, new enabling technology and computing advances might make your innovation obsolete). And if you're far behind the wave (with a "me too" product), you have missed the opportunity entirely.

Making simulation easier has involved, at least in part, incorporating more of the specialized knowledge in the brains of mathematically inclined Ph.D. engineers into the software solution itself. So we hired some of the best mechanical engineering thought leaders — back then, ANSYS was mainly a mechanical engineering simulation company analyzing the structural components of products for strength, toughness, durability, etc. — to work with our software development experts to transfer their knowledge to the software. At the same time, they thought hard about each step in the simulation process to make it more intuitive, creating menu-driven human–machine interfaces to replace arcane code-based input instructions.

Responding to Product Evolution

While implementation of these changes in our software solutions was expanding the simulation market, the nature of the products being developed started to evolve. In the past a mechanical device was made up of mechanical components, but increasingly electronics were being incorporated into the same device. The microelectronics being developed were combined with mechanical components to produce electromechanical devices that were capable of better sensing and control of the machines they were part of. This trend accelerated as electronics continued to get smaller.

But combining the physics of mechanics and electronics made product development more difficult: a complete virtual prototype had to include both types of physics to be valid. The number of new variables involved, and how electronic properties affected mechanical performance and vice versa, rapidly increased the number of prototypes a company had to investigate. The demand for simulation solutions increased, and the idea that simulation had reached a plateau began to fade.

To keep up with these new requirements, ANSYS had to evolve to handle electronics simulations involving electric and magnetic fields, integrated circuits, radio frequency signals, etc. The era of multiple physics simulations was born, and the challenges we faced multiplied. It was not long before other physics were included in the mix: fluidics, heat transfer, and embedded software modeled as another component in a virtual prototype.

Multiple physics simulation is a sequential process: You do a structural analysis and then you do a thermal analysis, maybe followed by a flow analysis. But in the real world, those aren't individual things. They all happen at once. For instance, if you're operating something in a hotter environment, the combination of heat and the mechanical vibration stress can cause failures where neither one alone would have had the same effect.

That led to multiphysics — as opposed to multiple physics — simulation. Multiphysics tries to look at all of those combined effects at once. So the structural, thermal and flow analyses take place simultaneously, passing changing variables back and forth automatically between solvers. This process eventually converges on an optimal solution that takes all of these interconnected physical properties into account, producing a holistic approach to managing the multitude of conflicting trade-offs.

If this sounds complex, it is. But once again, we had to focus on making simulation easier so it could be done by more engineers even as the complexity increased. We had to develop a platform that enabled various physics solvers to work together seamlessly, so engineers could perform simulations without excessive training. The resulting ANSYS Workbench platform does precisely that, and it continues to grow as the needs of our customers expand. Workbench helps our customers to build a complete virtual prototype of an entire system, not just individual components.

IoT is a logical evolution of product design

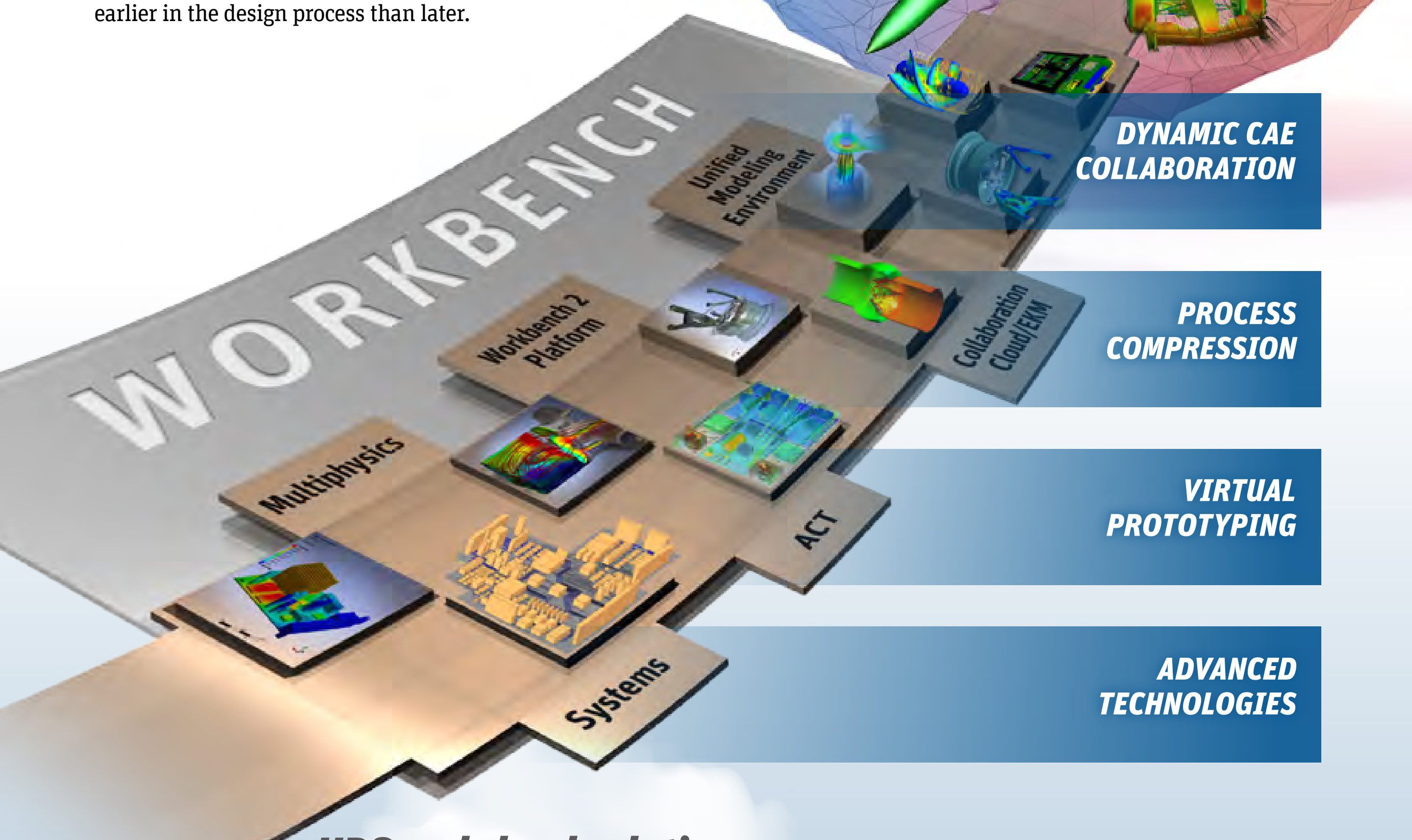
Simulation is really the only way to understand how products are going to behave in an increasingly complex, regulated and demanding business world.

Keeping Simulation Flexible

We also learned that many of our customers had unique software that they had created in-house to give them an advantage over competitors, or because there was no commercial software available to perform a critical task. Whatever the reason, they had to be able to integrate their custom software with ANSYS solutions to optimize their simulations. So we made Workbench flexible, enabling customers to plug in their own software and seamlessly run simulations that combined the power of our physics solvers with their unique expertise.

We'll make simulation easier even as products get more ***complex,*** *so every engineer in your organization can use it to save you* ***time and money.***

As simulations became more complex and companies required more innovation to compete, high-performance computing (HPC) and the cloud were necessary to speed up product design and reduce costs while ensuring reliability. We responded by making it possible to use HPC and cloud solutions to produce higher-fidelity simulations of products, which enabled engineers to look at complex interactions and see not only where something failed but why. Simulation began to be used earlier in the design process and throughout it, instead of just at the end as a final verification point. This saved cost, time, computing and personnel resources — it's cheaper to make changes earlier in the design process than later.



HPC and cloud solutions *produce higher-fidelity simulations of products, enabling engineers to look at complex interactions and see not only where something failed but why.*

The Way Forward

Recently, some of our customers have started to use our simulation solutions for a purpose we and others had long ago anticipated: to monitor the operation of systems and predict when maintenance will be needed, because unscheduled downtime is considerably more expensive than scheduled downtime. They do this by creating a "digital twin" of the system — a virtual copy of their product that can be used to determine what the expected behavior of the actual product should be. If the real-world system begins to deviate from the digital twin's behavior, that's an indication that something is wrong. The digital twin can help you diagnose the problem and schedule the downtime to fix it.

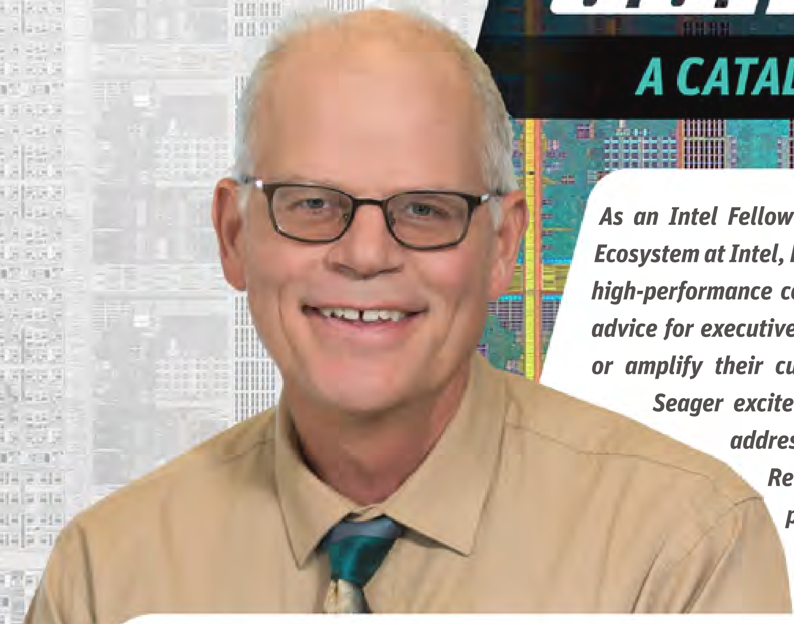
Though it may seem like something out of science fiction, perhaps one day we'll have enough computing power and sufficiently advanced software to produce a complete virtual prototype of the entire Internet of Things — effectively, a digital twin of the IoT — to monitor its workings and accommodate every new change to the system.

Regardless of whether we ever get that far, it's clear that simulation is really the only way to understand how products are going to behave in an increasingly complex, regulated and demanding business world. We'll continue trying to surf just ahead of the wave, so we can see what's coming technologically, and constantly improve our software to deal with the changes that our customers will be facing. We'll make simulation easier even as products get more complex, so every engineer in your organization can use it to save you time and money.

Today, about one in six engineers is using simulation; we've long been predicting that by 2030 every engineer will do so. We'll stick by that prediction, with full knowledge of the perils involved. We look forward to working with you so that we can reach this goal together.

Jim Cashman bio

Jim Cashman is the chief executive officer of ANSYS, Inc. Prior to joining ANSYS, Cashman held positions at PAR Technology Corporation, Metaphase Technology, Inc. and Structural Dynamics Research Corporation. He is chairman of the Pittsburgh Technology Council and a past board member of the Carnegie Museum of Natural History. Cashman's experience includes senior responsibilities in technology, product and market strategy management, as well as sales, operational and international functions prior to his general management role with ANSYS for the past 15 years. His long-standing vision and well-diversified background are key components of the company's board structure and effectiveness.



HIGH-PERFORMANCE COMPUTING

A CATALYST FOR CHANGE

*As an Intel Fellow and chief technical officer for the HPC Ecosystem at Intel, **Mark Seager** has a unique perspective on high-performance computing. He is glad to offer practical advice for executives who want to begin investing in HPC or amplify their current efforts. But what really gets Seager excited is the potential to apply HPC to address global challenges like cancer. Recently, he shared his thought-provoking views in an interview with* Dimensions.

DIMENSIONS: As the visionary for high-performance computing (HPC) at Intel, what are the major issues you focus on? What are the key challenges in HPC today?

MARK SEAGER: While we've made tremendous progress in HPC over the last 10 years, there is still huge potential for additional progress. Our goal at Intel is to develop technologies that support exascale computing — where a billion calculations can be made every second. To reach that goal, clearly we need to design more efficient systems that improve performance while reducing power consumption. We need to improve our ability to program highly parallel systems with more efficient message passing and improved threading to enable parallel computing built on Intel's Scalable System Framework. Finally, we must develop computing systems with greater resiliency, so they won't be overwhelmed by large numerical problems. If we can make progress on all these fronts, we can achieve the speed and efficiency improvements needed to support exascale computing.

DIMENSIONS: There's so much buzz in the business press about HPC today. What are the biggest misconceptions executives have about high-performance computing?

MS: Probably the biggest misconception is, "My company doesn't need to invest in HPC." The truth is that the majority of businesses can leverage the power of high-performance computing to manage their core tasks better, faster and less expensively.

Let's take the example of product design and development. Simulation solutions have eliminated a lot of time and costs by allowing engineers to solve problems in the virtual world, instead of building and testing physical prototypes. I think it's safe to say that simulation has shortened the average design cycle by 30 percent. In today's environment of intense competition and more frequent product launches, that's a significant advantage. However, to fully capitalize on simulation, most engineering teams need to work in a high-performance computing environment that's capable of handling large problems with relatively short design cycles.

High-performance computing can also help most companies manage the problem of big data. The Internet of Things is creating huge amounts of information about what customers want and how products are performing in the field. While this is certainly a positive thing, sometimes the sheer volume of information is overwhelming. For instance, when GE collects in-flight data on its jet engines — their stress level, temperature, noise, vibration and other characteristics — more than a terabyte of data is generated per flight. That's an extreme example, but today every company is collecting a lot of information, and HPC can help store it and analyze it much faster and more cost-effectively.

DIMENSIONS: As companies begin their HPC journey, what's the biggest obstacle to getting the capability up and running? How can executives overcome this obstacle?

MS: The biggest challenge is our tendency, as executives, to require a complete business case — and demonstrate a probable return on investment — before we make any kind of move. Most management teams ask the IT staff to prove that HPC will create a proven "win" before a new system is approved. Certainly executives need reassurance that there will be business benefits, but this cannot become a slow, time-consuming process that keeps the company from moving forward. Agility and speed are needed to keep up with the evolution of HPC and avoid being left behind.

Today, HPC is cheaper and more accessible than ever, as we're all just a credit card away from using our public cloud provider of choice. Executives don't have to sign off on a whole new technology system, but they need to do something now, before they miss any more opportunities to benefit from HPC. There's a huge economic benefit that can be gained from high-performance computing. Again, just think of the impact we've seen in product development. Executives need to take the initiative and begin to define what those benefits might be for their own business.

DIMENSIONS: Looking five to 10 years out, what new impacts do you see HPC making in business applications?

MS: I think there are a few trends we should all keep our eyes on. One is the continued growth of the Internet of Things, but in unexpected ways. Today we have all these personal electronics, like phones and tablets, generating and exchanging data. But tomorrow we're going to have smart refrigerators that communicate when we're running out of milk. Complex systems, like aircraft with modern jet engines, collect vast quantities of data during flights. Everything around us is going to become more intelligent and more interactive. As that happens, we're going to need next-generation HPC to manage all that information.

"Everything around us is going to become more intelligent and more interactive."

I also believe we're going to see artificial intelligence become more commonplace and more practical. Right now, large enterprises design many products via simulation, and many of these simulations still require manual human interaction and are iterative. What if the design process itself became more automated and machine-led? Human designers have limitations. For example, they consider the look of a product, its aesthetics. Artificial intelligence is not limited by this human design approach; it takes the design parameters and arrives at a solution that is constrained only by the specified design criteria. We could see some dramatic new breakthrough products if we can incorporate artificial intelligence and HPC into different phases of product development.

We're also going to see more simulation capabilities integrated into the product development process. Already we've seen simulation create a dramatic impact, but in the future simulation will not be a separate step. It will be built right into design software, so that scenarios can be modeled, and results realized, in real time at every stage of product development.

Finally, additive manufacturing — or 3-D printing — is set to revolutionize how we make products. As the maker movement takes hold, manufacturing is becoming democratized. That means, eventually, simulation software and other professional design tools will need to be available and easily accessible to entry-level users. That's going to create an incredible depth and breadth of engineering data, including open source and inexpensive proprietary design IP, and HPC can help facilitate how all that information gets stored and processed.

When the above trends are coupled with virtual and augmented reality, the time to design new products can be radically reduced because one will be able to naturally interact with high-resolution, time-dependent 3-D data quickly. With AI-generated augmentation of the virtual scene, data trends, anomalies and suggestions for improvement will provide deep levels of domain expertise to a wider range of users. This will drive the expansion of HPC adoption beyond the traditional white lab coat elite and contribute to the democratization of manufacturing.

> ***"High-performance computing can contribute to solving many global challenges that involve studying large amounts of data — including climate change, energy discovery, national security, and nutrition and hunger."***

The Intel® Xeon Phi™ processor is a foundational element of Intel® Scalable System Framework.

Intel at a Glance

2015 revenues: $55.4 billion
Number of employees: 107,300
Headquarters: Santa Clara, USA

DIMENSIONS: What excites you most about the future of high-performance computing?

MS: Clearly, businesses are going to continue to realize significant financial and strategic benefits from their use of HPC. But, personally, I'm really passionate about the power of HPC to improve quality of life by extending HPC use in broader challenges like human health and disease.

For instance, the National Cancer Institute Moonshot initiative has been created with $1 billion in U.S. government funding with the goal of dramatically impacting cancer treatment research. There is so much data out there about the genetic characteristics of cancer patients, historic responses to certain treatments, geographical concentrations of cancer patients and other relevant issues. But it's absolutely impossible for human researchers to sift through this mostly paper-based information, separate the critical from the trivial, and draw reasonable conclusions. To accomplish that, we need artificial intelligence and analytics, supported by HPC. That's the only way health-related projects like this can digitize these patient records with informative annotations and identify patterns over large numbers of patients and years of treatment.

High-performance computing can contribute to solving many global challenges that involve studying large amounts of data — including climate change, energy discovery, national security, and nutrition and hunger. The implications are enormous.

Recently, I watched the movie "*Spotlight*", which focused on a team of investigative journalists and their search for the truth. They were going through all this paper — public records, newspaper archives, church directories — and trying to make connections. I thought to myself, "That era is coming to an end." And it should come to an end, because there is so much latent information and insight locked up in paper records. Today, we have a wealth of technology tools for scanning digital data and extracting information to make connections between data records, finding patterns or anomalies and analyzing trends. Soon those technology solutions might even be able to make autonomous recommendations via machine learning and cognitive computing. As that happens, it's going to accelerate our progress in many avenues of research that have the potential to change our lives. Without high-performance computing, that future would not be possible — and that's why I find my work at Intel so gratifying.

About Mark Seager

Mark Seager leads HPC strategy for Intel's Enterprise and Government Group and represents Intel on the OpenSFS board of directors. At Intel, he is working on an ecosystem approach to develop and build HPC systems with exascale capabilities. Previously, he was assistant department head for Advanced Computing Technology within the Integrated Computing and Communications department at Lawrence Livermore National Laboratory. He received a B.S. in mathematics and astrophysics from the University of New Mexico at Albuquerque, as well as a Ph.D. in numerical analysis from the University of Texas at Austin.

TEAMWORK DRIVES RED BULL RACING

Success in Formula One requires an enormous amount of coordination. Collaboration between engineering, IT and manufacturing allows the team to innovate rapidly, introducing new updates between every race. Teamwork, technology and a single goal all contribute to on-track performance in a sport where success is measured in fractions of a second.

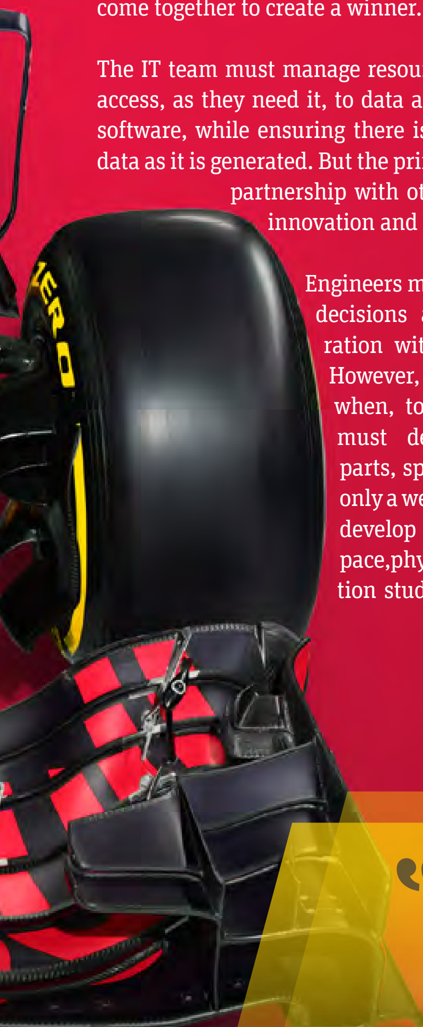
By Matt Cadieux, CIO; **Nathan Sykes**, Head of Numerical Tools and Technologies; and **Al Peasland**, Head of Technical Partnerships, Red Bull Racing, Milton Keynes, UK

The pinnacle of car racing is Formula One, and Red Bull Racing is among the elite. Although a relatively young team for Formula One, Red Bull Racing stands out for its success and innovative approach to racing. All 700 members of the Red Bull Racing family are integral to the success of the team. A commitment to using all available tools — from sensors to advanced analysis — provide the skilled and expert team with the ability to overcome more experienced competitors.

Teamwork Provides a Winning Advantage

To be successful throughout a race season, teamwork is a critical factor. Each of the racetracks is different, so after each race the team applies different configurations, to meet new specifications. This rapid pace of change rewards those who are able to quickly innovate and iterate to find the best solution. In an industry where development cycles are measured in hours and days rather than months and years, communication and collaboration are essential. Each Red Bull Racing employee has a specialty, and it is a substantial team effort to come together to create a winner.

The IT team must manage resources so that engineers have access, as they need it, to data and to simulation and other software, while ensuring there is sufficient storage for new data as it is generated. But the primary role of IT is working in partnership with other departments to ensure innovation and create a winning car.



Engineers must constantly make design decisions and trade-offs in collaboration with the entire organization. However, time is a limiting factor when, to be competitive, the team must design made-to-order new parts, specific to each race. There is only a week or two to design, test and develop all of these updates. At this pace,physical testing and validation studies are not always a viable option. A car is shipped to a race with dozens of optional parts and tested three times before the race — twice on the Friday before the race and once on Saturday, before qualifying, after which teams are not allowed to make further changes to the car prior to Sunday's race. Red Bull Racing relies heavily on engineering simulation — testing the design in a virtual environment using computers — to help steer the design changes for the car. The short timeline means the Red Bull Racing team needs to have confidence in the engineering simulation.

During the trial runs before a race, the driver's input regarding the car's performance is vital. If he is not confident in the car's performance, then he will not push the car to its absolute limit, and the performance of the car and the team suffers. Drivers need to be aware of the enhancements made to the car, and driver input on what works and what doesn't is important for the engineering team.

Red Bull Racing Driver
DANIEL RICCIARDO

> ***"Speed is really important and it's not speed just on the track, it's speed of our development process."***
>
> **—Matt Cadieux, CIO, Red Bull Racing**

The teamwork goes beyond the direct Red Bull Racing employees to include coordination with technical partners like ANSYS. ANSYS engineers work on-site with Red Bull Racing engineers to ensure that the team gets the most out of the software. ANSYS is invested in what Red Bull Racing does and is part of the team. Red Bull Racing's partners must provide suites of technology, fully integrated solutions, and results that are cutting edge and best in class.

Driving Down Lap Times

The airflow around the car is a major factor in how the car performs during a race. The car needs to be aerodynamic to quickly cut through the air, but the driver must maintain control. In addition, airflow is vital to cool the brakes and the engine, and to create downforce to keep the car on the track.

In the "old days" of Formula One, development was heavily focused on the wind tunnel. To maintain the competitive nature of the sport, regulations change frequently, and the amount of wind tunnel testing is restricted by F1 regulations. In addition, wind tunnel testing is cost-prohibitive and cannot always keep up with the pace of innovation because physical models for wind tunnel testing require time and money to build. It would be difficult to remain competitive in today's environment without employing simulation to help guide development and reduce the time between design iterations. Without simulation, the tweaks made to the cars between races would need to be smaller because their effectiveness could not be easily tested. In addition, simulation gives engineers the ability to see the entire air flow around the various elements of the car and even determine how the air is reacting downstream.

Simulation is vital to Formula One racing. It allows teams to test design changes quickly in a virtual environment. A generic simulation is shown.

Using ANSYS software, Red Bull Racing can quickly run through each development on the car and make multiple iterations on those changes each day. This allows the team to make more substantial improvements that are apparent in the wind tunnel and on the track.

Leveraging the Internet of Things

Formula One racing is one of the most technologically driven sports. It requires optimizing the system of car and driver to reach their full potential. It is a data-driven business, and often races can be won or lost by the work that goes on before the team even arrives at the racetrack. The car is improved based on all of the available information and tools, and tuned to the individual driver. The consequence is that Formula One teams like Red Bull Racing have long been taking an Internet of Things (IoT) approach to instrumenting and analyzing their car.

The cars are fitted with hundreds of sensors measuring every element of the car's performance. This real-time data is used to micromanage the car, to provide advice to the driver (for example, when a pit stop is required) and to get the most out of the car during the race weekend. This data helps ensure that the driver and the car are optimized as a system. It also assists the team in assessing the health of the car and predicting any reliability issues before they become a problem. This data is fed back to the design engineering team to use as simulation input to optimize the car's future performance.

"**Success** *is making sure that every component that hits the track works and takes us forward, which means we are out-developing the competition.*"

—Nathan Sykes, Team Leader for CFD and FEA

Teamwork, technology and a single goal all contribute to winning in a sport where success is measured in fractions of a second.

A Single Goal

Success is winning points on the racetrack and ultimately winning championships. Red Bull Racing has been fortunate to have been very successful for over a decade, with currently four World Championships.

Success on the track stems, in part, from pushing the business quickly and efficiently, and being agile enough to adapt to changes during the season. Winning with technology means having the best possible development process to efficiently design the fastest car. This means ensuring that you trust and understand your tools and processes.

On-track success requires collaboration at every level within the team — driver skills, engineering expertise and supporting service. Teamwork within the entire Red Bull Racing drives on-track performance.

Matt Cadieux

Al Peasland

Nathan Sykes

Red Bull Racing at a Glance

Employees: 700 *Headquarters: Milton Keynes, UK* *First Season: 2005*

The IoT and the Economics of Data

Are You Ready?

The media is filled with statistics about the exponential growth of the Internet of Things — how many devices, by what year and who is using them. But, for executives, focusing on the "things" themselves misses the point. The real value of the Internet of Things for businesses lies in the enormous volume of data and insights generated by the billions of devices. Harness the power of that data, and your company will take a leadership role in today's information-driven world.

By Susan Athey, The Economics of Technology Professor
Stanford Graduate School of Business, Stanford University

If you follow the business media, it's hard to ignore the constant buzz about the Internet of Things (IoT). There is a seemingly endless stream of stories and statistics about how quickly electronic devices proliferate, and how growth is likely to impact us in our professional lives. Examples include the value created by increased employee productivity, the introduction of automation and robotics, and the opportunities to introduce new, smarter versions of existing products.

But the business media seldom focuses on the most valuable benefit of the IoT: the invisible mountain of data and user insights generated by the billions of devices in use around the world today. By mining this data, companies can optimize their decisions. For example, consumer products companies and retailers can learn where people are shopping, gauge the effects of promotions and generate more-customized assortments. Industrial products manufacturers can gather field data to build more-durable equipment and perform predictive maintenance and repair. Physicians and medical service companies can monitor patients' well-being on an ongoing basis and provide personalized treatment to deliver better outcomes for the patients, insurance companies and the medical industry.

The possibilities are endless. The vast amount of real-time information that the IoT generates has the power to change corporate destinies and level the playing field between industry leaders and niche players. Yet to date, companies seem to focus on getting the infrastructure, security and foundations laid, while the data is underutilized as a source of strategic advantage.

Rethinking Traditional Business Models

With so much at stake, why are most companies under-leveraging the big data available to them today? The answer is actually simple: The typical business is not organized or equipped to change the way it makes decisions or becomes fundamentally data-driven.

While many businesses have begun to collect and store data, they lack the technology, the systems and the algorithms to unlock its potential. Executives pick their battles and focus on the short-term questions with immediate financial value. For example, they look at historic sales to create a forward-looking sales forecast for the next several months. They write a purchase order for products or materials based on last year's consumption patterns.

These are certainly valuable applications for data, but they don't impact the long-term future of the business. Executives need to frame larger, more-strategic questions — such as "What are the emerging unmet needs of our customers?" — and then mine the data they already have to seize a sustainable competitive advantage, for example by using data more effectively than competitors, gaining market share and continually improving their use of data.

> *"The typical business is not organized or equipped to change the way it makes decisions or becomes fundamentally* ***data-driven.****"*

Many companies have tried to solve this problem by investing in larger IT departments with faster processors and bigger databases, but capitalizing on big data is not a technology problem. Turning data into a strategic weapon means creating new business models that bring strategic analysis to the forefront — and also anticipating where new competitors might emerge in a shifting landscape, where competing firms may gain a strategic advantage when they are able to better monetize data they create. New staffing capabilities and departments must be created that combine technical expertise in data management with the business expertise needed to interpret and apply that information strategically.

This is a new set of skills that is hard to find today, as academic programs tend to focus on "technical track" versus "management track" — failing to produce graduates with the flexible, diverse skill sets needed to understand both IT and business. This problem should eventually be addressed, as business schools are already refining their curricula to increase the focus on technology and big data, but in the short-to-medium term it will remain a challenge.

The Need for New Analytic Tools

In addition to creating new business models and internal competencies, executives need to rethink their foundational toolkit for managing data. Just as ANSYS simulation software helps to solve large, computationally intensive problems via automation and iterative solving, similar tools might be developed and applied to sift through large datasets and identify the truly meaningful insights that can alter the future of the business. Through simulation and scenario modeling, business problems might eventually be addressed in a virtual space via the application of data, just as ANSYS solves engineering problems.

"There is so much uncertainty about big data that most companies have become risk-averse — so afraid to make a mistake that they fail to do anything at all. This is the single greatest error executives can make."

Where will these tools come from? It's hard to predict, but technology pioneers like Microsoft and HP are working on developing standard, general-purpose data analytics that can be customized to different industries. Google and Amazon already have distribution systems in place to deploy new, industry-targeted software solutions.

Some larger manufacturing companies, including GE, have already developed internal analytics tools. They could eventually commercialize these solutions and sell them in other industries; GE is headed in that direction with its Predix digital industrial software solutions and services.

And, of course, one strategy already in play is building an internal analytics department from the ground up — though most companies lack both the resolve and the resources to accomplish this.

The Biggest Risk: A Failure to Act

There is so much uncertainty about big data that most companies have become risk-averse — so afraid to make a mistake that they fail to do anything at all. This is the single greatest error executives can make. Whatever their industry or business focus, companies must take action to better manage and apply data, or they will be left behind as the explosion of the IoT creates more and more information every day.

Small, entrepreneurial businesses actually are taking a leadership role today in embracing and leveraging the power of big data. These companies are recruiting new employees with the right mix of expertise and investing in internal analytics capabilities. Why are they on the forefront? Because start-up companies are characterized by a risk-taking, "fail fast and fail often" mentality that is lacking in larger, more-established companies. They recognize the value of trial and error, and they embrace change.

Whether you are ready or not, the rise of the IoT and the explosion of big data are going to impact your business model, your products and services, and your customers in ways you can't imagine yet. You need to start thinking about the most critical questions your business needs to answer, and begin devising a practical strategy for mining your available data to get accurate answers. The solution is not going to emerge overnight, and it's not going to be perfect — but you need to start attacking the problem of big data management and mining now to avoid getting left behind.

About the Author

Susan Athey received a Ph.D. in economics from Stanford and a B.A. in economics, computer science and mathematics from Duke University. Before joining the faculty at the Stanford Graduate School of Business, she taught in the economics departments at MIT, Stanford and Harvard. Her current research focuses on the economics of the internet, marketplace design auction theory, the statistical analysis of auction data, and the intersection of econometrics and machine learning.

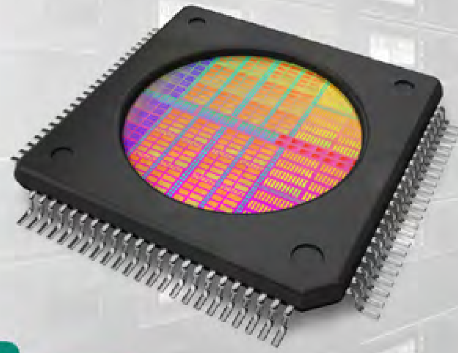
Stanford University at a Glance

Endowment: **$22.2 billion**

Number of students: **6,994 undergraduate, 9,128 graduate**

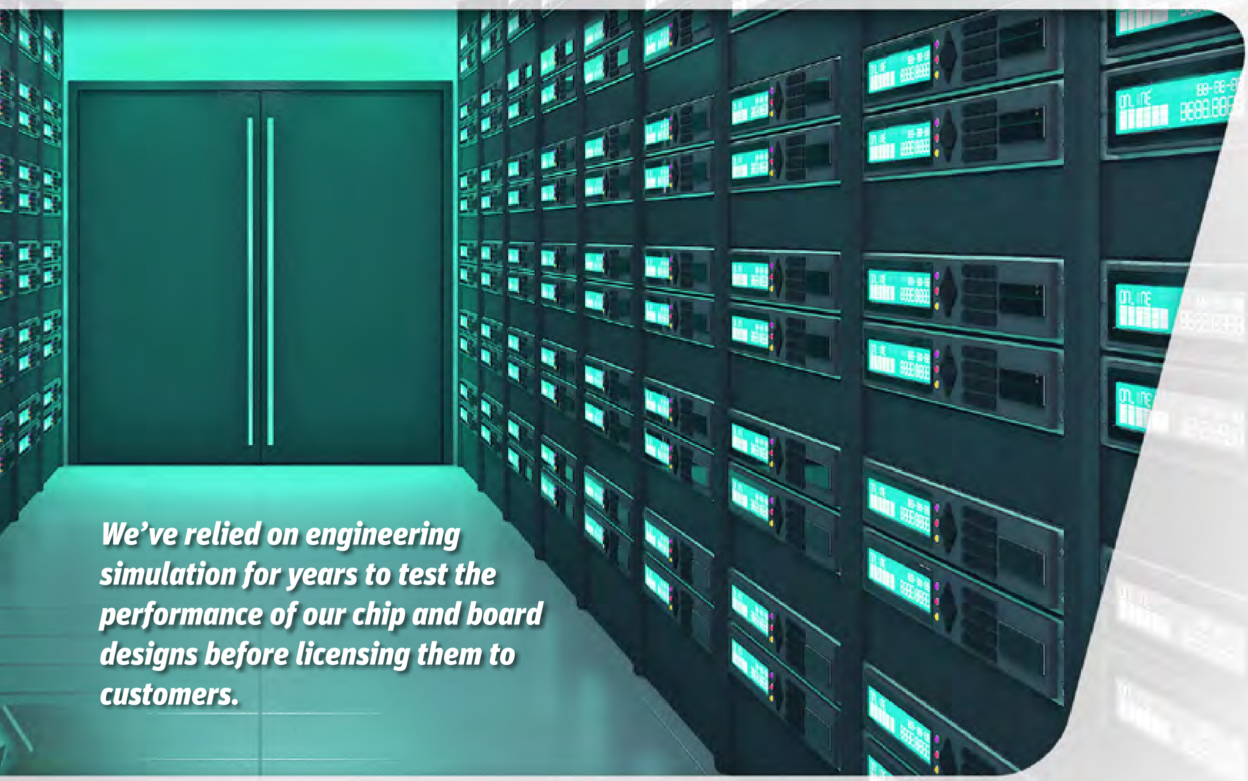
Location: **Palo Alto, USA**

THE INDUSTRIAL IOT: CAPTURING THE POTENTIAL



Ravi Thummarukudy

The Internet of Things has revolutionized our personal lives, providing us with new levels of convenience, productivity and connectivity. However, the business world has been slower to adapt wireless devices and digital technologies. Here, Ravi Thummarukudy of Mobiveil — a technology leader in the data center, networking and IoT markets — discusses why companies have been slow to embrace the Industrial Internet of Things, along with the opportunities that await them once they do. He also describes some strategies for beginning to realize the benefits of emerging IoT technologies today.



DIMENSIONS: Can you tell us what Mobiveil does and how the company plays a central role in the Internet of Things (IoT)?

RAVI THUMMARUKUDY: Mobiveil specializes in developing silicon intellectual properties (SIP), platforms and solutions used in data centers, communication networks and many other Internet of Things applications. In essence, we are a fabless semiconductor company but we don't produce chips. We license our chip design and implementation technology to customers as an intellectual property. Our customers are leading semiconductor businesses working on complex chip and board designs, but they don't want to start from the ground up. We provide them with the building blocks they need to deliver speed, capacity, power and other performance features to their customers — who include the leading electronics companies producing technologies for the Internet of Things. Because we serve this market, we have a unique perspective on the future of the IoT.

DIMENSIONS: What special engineering challenges has the explosive growth of the IoT created?

RT: One of our key focuses at Mobiveil over the past several years has been designing and delivering the right communications and connectivity functions. It's no longer enough to see each board or chip as an independently functioning unit. In the IoT, everything is connected. The products of company A must effectively communicate with the products of companies B, C and D. In response, we've created many standard interfaces that ensure this integration. These interfaces are the "secret sauce" that our customers value, because they know that communication and connectivity are being built in from the earliest design stages. We've relied on engineering simulation for years to test the performance of our chip and board designs before licensing them to customers. Our licensed knowledge helps to ensure that the Internet of Things is robustly engineered to maximize the performance and reliability of connections among all the different "things" that exist in today's heterogeneous technology environment.

DIMENSIONS: Given your unique perspective, what is the most exciting development you foresee for the IoT over the next several years?

RT: Much of the excitement and buzz about the Internet of Things today centers on the way it will impact our personal lives. We'll have connected homes and smart appliances that anticipate our needs for comfort and convenience. Drones will deliver our packages. We'll be wearing more and more electronics. This captures our imagination, and with good reason.

But I believe the bigger growth area will be leveraging the IoT in business applications — often referred to as the Industrial Internet of Things (IIoT). Just as smartphones and tablets have revolutionized our personal lives, technology has the power and potential to change our manufacturing facilities, our warehouses, our offices and our transportation networks. Unfortunately, the business world has been slower to discover and adopt these emerging technologies, even though the payoff could be enormous. I think we will see this trend reverse itself over the next few years, and we will see companies accelerating their adoption of IoT technologies. Eventually, strategically applying the IoT in an industrial setting will be recognized as delivering a competitive advantage. As market leaders adopt the Industrial Internet of Things, other companies will have to follow suit.

DIMENSIONS: Can you give us some examples of how the IIoT might benefit the typical company?

RT: Certainly there is a huge opportunity for plant automation. Manufacturers can gather data about customer demand, transportation capacity, materials availability and other real-time business conditions to run their production facilities much smarter and more cost-efficiently. Artificial intelligence can begin to drive many of the decisions about what to make, when and in what quantity — decisions that are largely made by humans today.

Remote equipment monitoring is another area in which the IoT can make a major contribution. Aircraft engines, undersea equipment and implantable medical devices are just a few examples of equipment that might be hard to monitor and control today. By installing sensors on these types of equipment, gathering data and analyzing it in real time, companies can predict and prevent many cases of mechanical failure — as well as schedule maintenance in a more cost-effective way, based on real-world conditions and not educated guesses. Future product development can obviously be significantly improved if we have a clearer understanding of how products are actually performing in the real world.

DIMENSIONS: Why has the business world been slower to embrace the Internet of Things than the consumer market?

RT: There are a number of reasons. Probably the most important is that companies have a lot more at stake. If a consumer buys a personal fitness monitor and it doesn't work as expected, that's a relatively minor problem. But if executives are trusting technology to manage their production facilities and meet customer commitments, the cost of failure is obviously much higher. Customers could be lost, and profit margins could disappear. For many enterprises, 24/7 operation is critical to their success, so it can be very risky to adopt any new technology model. While the IIoT offers a significant payback, sometimes it's easier for executives to just stick to "business as usual" and realize reliable results.

I discussed earlier how Mobiveil helps to ensure connectivity and communication. Openness and collaboration with business partners is highly valued in today's world. But anytime a company connects to a partner — or the cloud — there is an inherent security risk. No one wants to allow external parties to have the power to intercept data and gain control over a production facility, a plane in flight or an electric utility. That's a very real concern that must be addressed before most businesses will be willing to create real-time, device-based connections with third parties.

The IIoT is also going to create new power demands as increased volumes of information are collected and stored. The multitude of sensors and devices deployed around the world will need to be supplied with power in a reliable, cost-efficient manner. In addition, companies will need to create or access data centers where they can process and analyze their new insights about customers, plants, equipment and other factors that affect their success. Not only will these data centers consume large amounts of power, but they will be accompanied by practical problems such as cooling needs and physical security requirements.

These are not minor concerns. When you consider all these new requirements and risks, it's really not surprising that businesses have been slow to invest in the Industrial Internet of Things.

DIMENSIONS: What can businesses do to mitigate these factors and speed up their adoption of emerging technology?

RT: In the short term, the clear answer is to partner with established experts who have already figured out these issues. It is simply too costly and time-consuming today to build an independent IIoT capability — and the required knowledge and technology resources are readily available.

ANSYS recently teamed up with Tata Consulting Services as part of the GE Predix early adopter program to demonstrate how engineering simulation can be intimately integrated into the industrial internet ecosystem. One example demonstrated anomaly detection in a gas pipeline.

For example, there are many service providers around the world offering affordable cloud storage that can be accessed by anyone. This cost-efficient option enables any company to begin collecting new data via the IIoT and applying it to pressing challenges. One caveat is that most businesses store entirely too much information; executives need to separate the truly useful data from the unimportant, then only store the most essential insights that will actually be helpful. This will help minimize their outsourcing costs.

A number of trends are making cloud storage more affordable every day, putting it within easy reach of any enterprise. Many service providers have addressed the power and thermal issues associated with large data centers by constructing facilities in cooler climates such as Eastern Europe, and designing buildings with low cooling costs as a primary goal. This allows cloud providers to reduce their service fees. In addition, the transition from magnetic storage systems to emerging flash storage technology — which is a magnitude faster in terms of data retrieval time — is bringing down the time and costs involved in data processing. Large, data-intensive companies like Amazon and Google have already made this transition, and we can expect others to follow suit.

While data security is a huge challenge, there are certainly experts who can help address this issue as companies collect data from devices and sensors, as well as interact with trading partners and cloud providers. This is a well-founded concern that must be thoughtfully considered, but ultimately it should not be a deterrent to capitalizing on the IIoT.

Until internal capabilities for data analysis — which is one of today's fastest-growing career fields — are built, companies can access third-party expertise in this area too. Mining data and identifying key insights are specialized skills, but many firms today offer this expertise. With today's software-centric data-center architecture, many third-party analytics applications could be run on the collected data to provide for the best management insight and decision making.

Collecting the right amount of data, ensuring the right level of security, and applying the right amount of data processing at the right location are all key challenging questions that need to be answered for each enterprise. Eventually, I believe the cloud will become smarter and actually incorporate analytics along with compute and physical storage. That's when we'll really see an explosion of the Industrial Internet of Things.

About Ravi Thummarukudy

Ravi Thummarukudy has over 28 years of experience in the semiconductor industry. Before joining Mobiveil as CEO, he was a co-founder of GDA Technologies, a privately held design firm offering end-to-end solutions for semiconductor product development. Prior to this, Thummarukudy held global business and technology management positions at Cadence Design Systems, Tata Consultancy Services and the Indian Space Research Organization. He has contributed articles to *Chip Design Magazine, Electronic Design, ISD Magazine* and *SiliconIndia*. He holds a B.S.E.E. from Mar Athanasius College of Engineering and an M.Tech. from IIT Madras, India.

mobiveil
Investors in Innovation™

Mobiveil at a Glance

Privately Held *Employees: 125* *Headquarters: Milipitas, USA*

SENSING THE FUTURE

When we think about the Internet of Things, most of us picture a smartphone, a tablet, a smart watch or a fitness monitor. Underlying all these devices — and many others that you don't see — are advanced sensors that collect critical information in real time. Tim Saxe, CTO of sensor technology leader QuickLogic, points out that most businesses are overlooking the strategic value of these sensors to generate insights on product performance, customer needs and other key strategic considerations. Here, Saxe offers practical advice for executives on joining the sensor revolution.

By Tim Saxe, Chief Technical Officer, QuickLogic, Sunnyvale, USA

Much of the excitement about the Internet of Things (IoT) has focused on the ubiquitous personal devices — smartphones, tablets, wearables — that have replaced the last generation of big, clunky, largely unconnected technologies. At QuickLogic, we believe the bigger revolution might actually be the emergence of a global "swarm" of sensors that complement these devices, gathering huge volumes of data with enormous strategic potential for most businesses.

Think about it: Everywhere you go, there are sensors — in your car, in your home and all around you — that improve your quality of life. They collect information on your location, needs, surrounding conditions and even physical well-being. The most obvious examples are consumer applications: the faucets and hand dryers we encounter in public bathrooms, the thermostats in our homes, and the GPS devices that automatically sense where our cars are while we're driving.

> "Think about it: There are sensors in your car, in your home and all around you that improve your **quality of life.**"

However, as the IoT grows in sophistication and complexity, unexpected new business-related applications for sensors spring up seemingly every day. Consider these examples:

- The newest hotels in Las Vegas have sensors installed in every bathroom, monitoring the water consumed by sinks, showers and toilets. Not only does this data help hospitality executives understand high-level water usage patterns, it actually helps to determine daily cleaning and maintenance schedules. If the shower in room 517 has not been turned on today, it does not need to be cleaned. If a restroom in the conference center has been used often, it can be scheduled for maintenance.

- More and more often, industrial equipment is rented on an actual-usage basis. Think of the large lights that illuminate construction sites at night or industrial floor cleaning machines. Increasingly, sensors determine how much time this equipment is actually in use, and feed this data back to the leasing company for billing purposes. Thanks to sensor technology, customers can now only pay for actual hours of service and not the time equipment is sitting idle.

- In the retail sector, product displays increasingly include sensors that can tell when a product has been removed from a peg or other fixture. Store personnel can intelligently restock products as they are depleted — and automatic replenishment to the store can occur as sensors interact with larger corporate technology systems.

- In the wine industry, grapes often ripen at different rates due to inconsistent water supplies. This leads to waste, since harvesting is a one-time activity across the entire vineyard. Now sensors are collecting data on soil moisture levels at various locations, spurring irrigation systems to water certain areas and leave others alone. This type of agricultural application has the potential to increase crop yields and solve the pressing global issues of hunger and nutrition.

While sensor technology has the power to deliver many benefits, fully leveraging its potential presents some significant challenges for both executives and engineering teams. These must be solved before the average company can fully capitalize on sensor technology to anticipate and meet customer needs, perform predictive maintenance, streamline and automate the supply chain, and accomplish other critical tasks.

EFFECTIVELY INTEGRATING THE THINGS

As the Internet of Things grows in size and scale, an obvious challenge is ensuring cross-platform integration and communication. After all, the full strategic value of the IoT can only be realized if information is shared and actionable across the entire business network.

As you think about the earlier example of products being sold from the retail store — with sales sensed at the shelf level — consider all the uses of this data. Employees can be alerted in real time to restock the display. New inventory can be shipped from the distribution center. Further back in the supply chain, materials can be ordered and new production can begin. Merchandising teams can eliminate slow-moving products, and marketing teams can promote the best sellers. There is so much to be gained from this data, but it has to be effectively shared across many operating systems and platforms, from the executive suite to the factory floor.

The companies driving sensor innovation are working to develop universal technologies that can integrate with many systems spanning today's diverse business environment. Eventually we might see the adoption of a global communications protocol, such as the low-energy Bluetooth® Smart standard, for linking devices — but, in the meantime, it is the job of companies like QuickLogic to design sensor technology for maximum scalability and integration. Our engineering team leverages advanced practices and technologies, including simulation, to ensure that our products are compatible with those of other IoT manufacturers.

POWERING THE THINGS

There are a number of aspects of the "sensor revolution" that are creating power-consumption issues. First is the sheer number of sensors in operation around the world today, with billions more coming as applications become more innovative and diverse. Second is the portable nature of most sensors. While wired connections are more reliable, power-efficient and cost-effective, relatively few sensors can be hard-wired. Most must instead rely on battery power.

Sensor-technology leaders like QuickLogic are engineering solutions to this problem with the aid of simulation, including designing sensors that operate on as little power as possible. Another potential solution is designing an energy-harvesting system into the sensors themselves, so that they become self-powering. For example, an agricultural sensor might be able to collect and store solar energy to support its own functionality. The heat from the human body — or the mechanical energy generated by a running shoe in motion — might someday power personal fitness monitors.

There are some energy-harvesting technologies that already exist; however, they are currently cost-prohibitive for the typical business. A coin-cell portable battery currently costs about 28 cents, while a solar cell costs three to four dollars. It's hard to justify this expense, even when long-term energy cost savings are factored in.

Market leaders in both energy and sensor technology are working hard to develop more-affordable, energy-efficient solutions. I believe we will see a much greater adoption of energy-harvesting sensor technologies within the next five years. A likely key to energy harvesting will be more simulation, both of materials and environments. Executives should keep an eye on developments that will place environmentally sustainable, cost-effective sensors within easy reach.

"A likely key to energy harvesting will be more simulation, both of materials and environments."

ENGINEERING THE THINGS FOR RELIABILITY

Many sensors, such as those installed in planes and cars, are absolutely mission-critical. If they fail, human lives are at stake. Sensor manufacturers rely on advanced tools, including engineering simulation, to deliver the high level of reliability needed to minimize risk and maximize long-term performance levels.

As applications for sensors grow in both number and diversity, an increasing concern is the ability of these product systems to deliver reliable results in harsh, unpredictable environments. Consider the agricultural example above, in which sensors are exposed to the extremes of temperature and weather over months or even years.

QuickLogic works in partnership with other companies to deliver not only the most durable and reliable sensors, but also the most rugged, structurally sound housings that protect them over time. Simulation plays a role in both these areas, helping engineering teams ensure that real-world performance is consistent and predictable — without investing a lot of time and money in prototyping and physical testing. As the demand for sensors rises, simulation helps QuickLogic and our partners meet market needs without sacrificing product robustness.

The new EOS S3 sensor processing platform is a multicore system that enables a vast array of concurrent sensor applications on smartphone, wearable and Internet of Things devices.

MANAGING DATA COLLECTED BY THE THINGS

The power needs of sensors are determined, to a great extent, by how detailed their data collection activities are. When it comes to capturing data, we've come to believe that the finest-possible level of detail is always best; but that attitude has contributed to the enormous power drain created by today's growing network of sensors. After all, highly detailed collection means higher data volumes, increased processing demands, more-complex algorithms and longer solution times, all of which consume large amounts of power.

Data collection that is too granular creates other practical problems. For instance, as data volumes increase, it becomes harder to separate vital, strategic insights from unimportant information. And as technology systems become overwhelmed, data needs to be purged more frequently — increasing the probability that something critical will be overlooked.

To fully capitalize on the IoT in our businesses, we need to shift away from the notion of "fully accurate" and embrace "accurate enough." Most sensors don't need to operate 24 hours a day, seven days a week, and they don't need to capture every single performance parameter. Today's artificial intelligence and machine learning solutions have the power to extrapolate key findings and identify trends based on smaller and smaller numbers of inputs. This means the typical company does not need to collect performance or sales data every single second of the day.

In an age in which we can collect an incredible wealth of data, occasionally we need to remind ourselves that this is not always the smartest or most cost-effective course. Making the most of sensor technology means understanding how to apply it in the most strategic manner, instead of drowning in a sea of big data that is too overwhelming to properly apply.

JOINING THE SENSOR REVOLUTION

With their power to collect real-time, real-world data on product performance, customer service needs, sales trends and other vital business parameters, today sensors are revolutionizing many industries. Most businesses can benefit from the ability of leading-edge sensor technology to gather insights that can help to reach their most important strategic goals.

What can executives do now? Perhaps the smartest course of action is to start thinking about what data you can collect, and how it can be used in unexpected ways. If you have equipment in the field — such as a generator or an oil rig — certainly you can monitor its uptime, downtime and overall performance parameters. But can you also schedule maintenance? Feed information back to the product development team so engineers using simulation can address any design shortcomings? Use environmental readings to optimize the future placement of any equipment? As big data volumes increase, it's easy to be overwhelmed just by collecting information and storing it. But don't forget to apply it strategically to your company's most pressing challenges.

Along the path to adoption, there are many issues to consider — including the cost of installing sensors, retrofitting existing equipment and ensuring the security of the data you're gathering and storing. These are not insignificant issues. However, given the potential of modern sensor technology to provide real-time insights with high strategic value, every executive today should consider how this often-overlooked aspect of the IoT can be applied to impact company-wide performance.

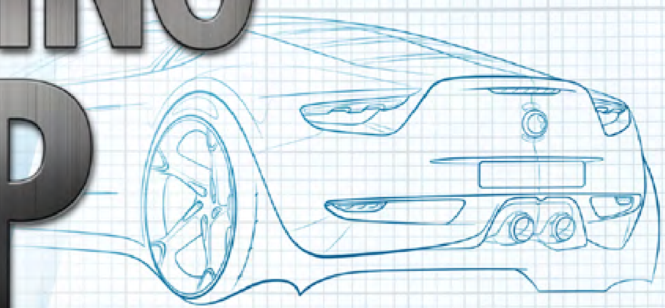
About the Author

Tim Saxe joined QuickLogic in May 2001 and has served as the company's senior vice president and chief technical officer since November 2008. Prior to joining QuickLogic, Saxe was vice president of FLASH engineering at Actel Corporation, a semiconductor manufacturing company. He was part of the founding team of GateField, which was the semiconductor division of Zycad, a design verification tools and services company. Saxe holds a B.S.E.E. from North Carolina State University along with an M.S.E.E. and a Ph.D. in electrical engineering from Stanford University.

QuickLogic at a Glance

2015 revenues: $19 million *Employees: 100* *Headquarters: Sunnyvale, USA*

REVVING UP PRODUCT DEVELOPMENT



Founded in 1916 and headquartered in Beinasco, Italy, Cornaglia Group develops leading-edge components for the world's automakers — including exhaust systems, intake systems, fuel tanks and air filters. When Massimo Marcarini was named director of R&D in 2012, his vision was ambitious: to completely transform the product development function at this relatively small 100-year-old company. Recently, Marcarini talked with **Dimensions** ***about how he accomplished this mission — while also reducing overall development costs by 24 percent.***

DIMENSIONS: What inspired you to join Cornaglia in 2012?

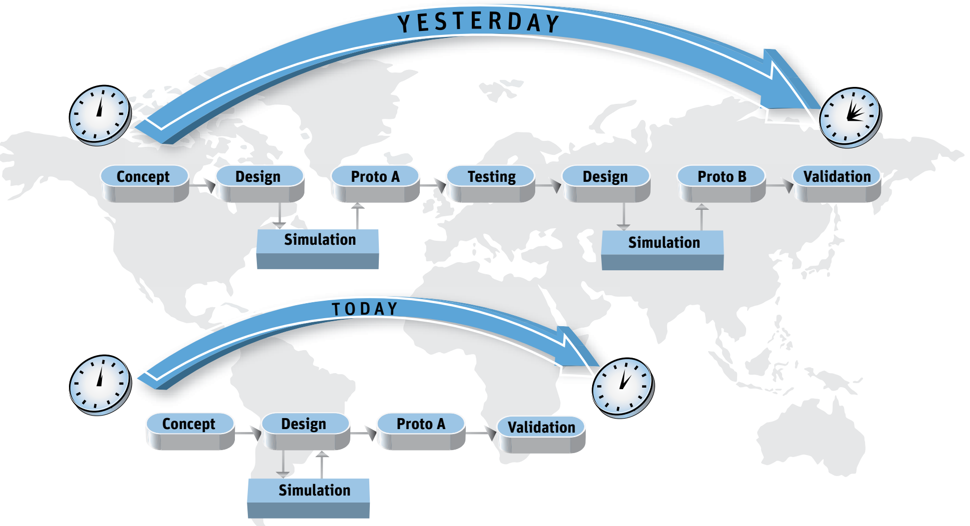
MASSIMO MARCARINI: I had spent four and a half years at Cornaglia in the 1990s as a research and development manager — so I knew the company had outstanding products and a commitment to hiring excellent people. As a smaller supplier to the automotive industry, Cornaglia has always recognized that it must innovate to remain competitive. When I rejoined the company in 2012, Cornaglia had an impressive 5,000-square-foot research and development center in Villanova d'Asti with 60 engineers. They were relying on older processes and building a lot of physical prototypes. Cornaglia was patenting an average of only three innovations projects per year. I looked at the situation and thought, "I can make a real difference here."

DIMENSIONS: Were there cultural issues that needed to be addressed? Or were the primary challenges centered on technology?

MM: Let me begin by saying that I believe Cornaglia has the greatest employees in the world. They are our most important asset and the single-greatest driver of our success. However, prior to 2012, our employees did not have the best environment for focusing on innovation. Our engineers were working in individual offices, not communicating, and concentrating on very narrow projects, such as one product feature or a single component. The mindset was, "I do my job, and you do yours." When I arrived at Cornaglia, we literally knocked down the walls and brought our engineers together in a collaborative, open-space work environment. People began to talk and share their development work. We began to think of ourselves as a supplier of value-added systems rather than separate components. Today our mindset is "It is our shared job to supply everything — and it all works as an integrated system." That is allowing us to deliver a new level of value to our customers.

DIMENSIONS: Other than tearing down walls, what other steps is Cornaglia taking to encourage engineering collaboration?

MM: We continually revise our processes and update our engineering organization to ensure that they meet our company's needs. We have to take into account continually changing input from the external world — information based on the evolution of our market, customers and competitors — as well as feedback from our company. Our duty is to analyze all this data and align ourselves to account for all these needs. An example is our move from a CAD-centric vision to a CAE-centric vision. This means that CAE engineers are part of the concept development process, and Cornaglia provides them with the tools to run a first-stage simulation. We've also initiated other organizational changes, such as introducing production people into the development team.



Previously, product development at Cornaglia was a complex, time-consuming seven-step process. Today it is a streamlined four-step process that leverages simulation at an earlier stage.

DIMENSIONS: As a supplier of value-added systems, do you find that your customers expect more from you than just high-quality components?

MM: Customers expect more and more. They need innovative products in terms of performance, technology, weight, size, cost, etc. The market requires suppliers that offer a systems integrator approach, someone to manage complex systems composed of mechanical, electronic and software components. Our customers want to simplify their technical and supply-chain contacts as much as possible.

Cornaglia has defined five-year innovation road maps for our products. The road maps are continually updated or customized as needed, and we systematically share this progress with our customers. We cooperate with many important companies like ANSYS and 3M to develop innovative projects and processes. Last but not least, we validate the final results of our projects with our customers.

DIMENSIONS: What were the steps in product development at Cornaglia historically — and what does the process look like today?

MM: Historically, the development cycle was composed of seven steps, including the construction of two different physical prototypes. Product flaws and weaknesses were identified fairly late in the cycle, when a lot of time and money had already been invested. Simulation had been used to develop prototypes, but was not employed at the earliest stages of design.

Today, we've reduced the design cycle to four steps. We use engineering simulation to verify product performance and address any issues in the first stages of design — before we build a prototype. We can test the product in a virtual environment and iterate on various designs to determine the best one before generating a costly prototype. Once the product is validated via simulation, we build a single prototype that represents a very robust design. This eliminates an entire round of design, prototyping and testing.

Such early use of simulation drives a lot of time and costs out of Cornaglia's development cycle. In addition, it has empowered our engineers to be much more innovative and creative, because with simulation they are working in a low-cost, risk-free environment, where it costs only time to create new design concepts.

DIMENSIONS: In addition to leveraging simulation at a much earlier stage, are you more sophisticated today in your use of simulation? For example, are you applying multiple physics?

Cornaglia at a Glance

2014 revenues: €19 million *Employees: 1,000* *Headquarters: Beinasco, Italy*

MM: When we decided to transform our product development function, we approached some key suppliers, including ANSYS, and said, "Help us make the best possible use of your technology." Let's face it, the provider knows the technology best — and they also know how the world's best engineering teams are applying it. I believe this collaborative approach is the ideal way to derive value from your technology investments. As a result, today we use simulation in a much more complex, high-level way — and we use more-advanced features of the software to replicate real-world phenomena, such as product wear and deformation. We've created a high-performance computing (HPC) environment and are using HPC versions of the software. In keeping with our new systems-level perspective, we're integrating multiple physics and beginning to apply design optimization tools to look at the whole product system. We partnered with ANSYS to develop a detailed five- to six-year plan that supports our simulation leadership. That plan includes hiring new employees, training them, and adopting leading-edge processes and proven best practices — not just buying new software.

DIMENSIONS: You have made a large investment in simulation and simulation processes. How do you know this is the right thing to do?

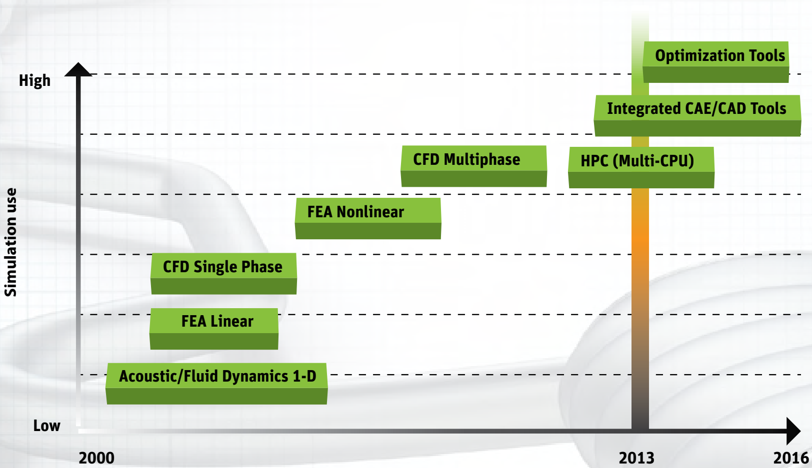
MM: I have absolute confidence in the simulation process and results, not only because I believe in this method, but I have proof in the numbers. Simulation models are validated by testing as well as comparison with customer and field data. Key factors are collaboration partners, like ANSYS or Politecnico di Turino, which help Cornaglia grow through tools, experience, market surveys and technology implementation. The team continually acquires competence, motivation and new skills from training. The confidence also comes from the company's investing in assets and people as well as revising the organization to equip the company with a new mindset.

DIMENSIONS: What are some of the tangible benefits Cornaglia has realized as a result of the changes you've made?

MM: One of the most impressive results is that we've reduced the overall cost of the product development cycle by 24 percent. That savings is due to the elimination of physical prototypes and test loops; instead, we use simulation as a virtual prototyping and testing tool. In addition, we've decreased the average time-to-market launch from 30 months to 20 months. As I mentioned earlier, Cornaglia was patenting only three innovations annually prior to 2012. In 2014 alone, we filed 10 patent applications. The financial benefits have been tremendous; in fact, I estimate that Cornaglia has earned a 10-times return on its investments in simulation technology. However, the strategic benefit is even more meaningful — because today Cornaglia is known as an innovative, system-level supplier that delivers dependable solutions and real customer value.

DIMENSIONS: What new challenges do you face, or what areas of improvement will you focus on next?

MM: We must grow our company through market penetration, gaining customers, developing superior products and managing complex systems. We must improve our engineering capabilities through constant process revision and improving our expertise. Cornaglia must become a systems integrator to develop products that are not just mechanical but that incorporate mechatronics, sensors, electronics and software.



Since 2012, Cornaglia has become much more sophisticated in its use of simulation, in keeping with its focus on innovation and its systems-level approach.

About Massimo Marcarini

From 2000 to 2009, Massimo Marcarini served as general manager for Motorola's research and development center in Torino, Italy. Under his direction, the center developed more than 40 different mobile phone models, filed more than 25 patents, and became Motorola's "global competence center" in many different areas of engineering development. When the center was spun off as an independent company in 2009, Marcarini served as its CEO and general manager. He joined Cornaglia Group as director of R&D in 2012. He holds a master's degree in aeronautical engineering from Politecnico di Torino and a bachelor's degree in science from Liceo Scientifico Isaac Newton in Chivasso. His M.B.A. in business development is from CEDEP University, France.