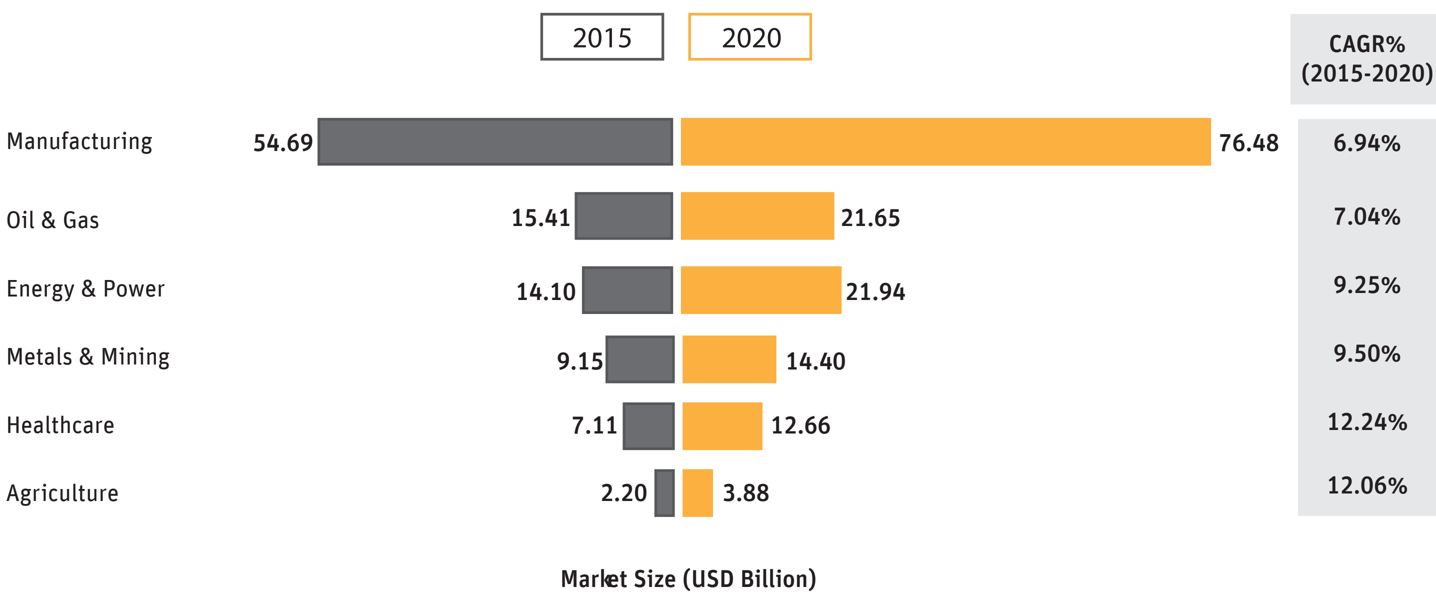
Engineering the Internet of Things: Industrial Equipment

The Industrial Internet of Things (IIoT) is changing the way the world designs, connects and optimizes machines. The advent of the IIoT brings together the things of the industrial sector (countless pieces of industrial equipment, machines, production facilities, plants), with a network (high speed routers, switches and gateways), and the cloud, which hosts the software and analytics for making decisions based on data from the things. In effect, the IIoT is connecting IT, product design and operational technologies.

And this is just the beginning. In a recent blog for Forbes, a team from Trefis wrote, "By 2020, the total technology spend on the industrial Internet is estimated to reach $514 billion, and the value created by the industrial Internet is estimated to rise to nearly $1.3 trillion, which translates to a return on investment of around 150 percent." Figure 1 shows that early adoption of the IIoT by manufacturers has led to improvement in the overall production process, accelerated transformation through use of industrial automation and robotics, and is expected to have impressive continued growth for the rest of this decade.



Source: World Economic Forum, Industrial Internet Consortium, Secondary Literature, Experts' Interviews, and MarketsandMarkets Analysis

Annual investment related to IIoT and anticipated growth over the next five years by selected industrial segments

Over the past few years the IIoT has grown beyond information technology concerns (gathering data, data processing and security, etc.) and now includes predictive maintenance of assets to reduce cost and nonproductive time, and eliminate breakdown and failure. One of the first steps in realizing the benefits of the IoT for industrial equipment is to create intelligent machines/digital products. As evident from consumer products like smartwatches, soon industrial equipment will also need to perform more than just a mechanical function, and must become smart or intelligent.

For industrial equipment, the idea is not to just add sensors everywhere. The strategy is to collect information that drives business objectives, resolves a technical or operational bottleneck, and meets industry standards and regulations. The major goals include optimization, reliability and new value creation (reducing downtime, extending asset life, reducing failure). This can be achieved through a combination of field data (sensors, operators) with non-field data (historical, simulated, physics-based analysis).

Many industrial companies are gearing up to benefit from the IIoT: industrial automation equipment providers, networking component providers, and original equipment manufacturers, along with operating companies across various industries such as metals and mining, agriculture, manufacturing, energy and power, oil and gas, materials and chemicals, and water and wastewater. The IIoT covers a broad ecosystem; both software and hardware solutions, and their applications, vary with each industry vertical.

ANSYS provides value to your IoT strategy through engineering simulation. For this report we have focused on selected solutions with a focus on electronics, systems and embedded software. ANSYS customers use our solutions in this space for design and simulation of industrial machines, sensors, RFID, industrial robotics, 3-D printing, power generation equipment, guidance and steering, flow measurement and control, and networking devices, to name a few.

2.0 The Value of Simulation and Five Core Engineering Challenges

As companies deploy their IoT strategies they realize that the industrial IoT infrastructure and products require a much higher level of reliability, precision, robustness, and innovation, all at a manageable cost. In a recent report, the Boston Consulting Group [1] listed simulation as a critical success factor in the connected economy to reduce product development cost by reducing the cost of physical testing, accelerating new product introduction and increasing product efficiency. To realize these benefits, companies can no longer afford to design in silos, or they will simply be out-innovated. The disruptors and innovators are going beyond traditional engineering discipline boundaries, resorting to multi-domain and multiphysics analysis.

Today’s equipment designer must consider that almost all new equipment will perform more than just a mechanical task. Digital equipment designers


Robotic systems can be modeled using ANSYS electronic, rigid dynamics, and mechanical systems.

must consider the electronic hardware they need, how the data is collected and communicated, and how various components work together and communicate as a unit to fit into the rest of the system and the ecosystem.

ANSYS simulation-driven product development solutions are used across the industrial ecosystem and supply chain, from large OEM and system integrators to component manufacturers. Our work with companies in this sector has highlighted five common engineering challenges and associated critical success factors. These are:

Size, Weight, Power and Cooling

The addition of IoT technologies, such as pervasive connectivity and sensing, brings higher density of electronic components, leading to additional size, weight, power, and thermal challenges. Consider thermal cooling of electronic control devices for deep well drilling, where equipment must operate in bottom well temperatures of about 200 C and equipment may be required to be rated to temperatures as high as 260 C. ANSYS solutions are used to reduce the power requirements of the electronics, reducing heat generation and helping to maximize the cooling of electronic modules for measurement while drilling (MWD), as well as guidance and positioning of the drilling systems.

Sensing and Connectivity

Smart connected products are ‘smart’ because they can sense their environment, communicate with other electronics, and enable decisions and outcomes. Connecting components to the Internet of Things requires replacing traditional industrial equipment with smart equipment. For example, smart pumps will be able to deliver diagnostic data directly to original equipment manufacturers and the operators. Combining equipment design, sensor placement and connectivity reliability can create costly physical prototyping. An automated design loop enables engineers to investigate and optimize their designs through hundreds of design permutation analyses without manual intervention. Recently, Jacob Vernersen and Nicholas Engen Pedersen of Grundfos Pumps published an article in ANSYS Advantage magazine VIX, Issue 3, in which they wrote, “The multiple physics simulation process reduced overall design time for the new pump design by 30 percent and saved approximately $400,000 in physical prototyping.”

Reliability and Safety

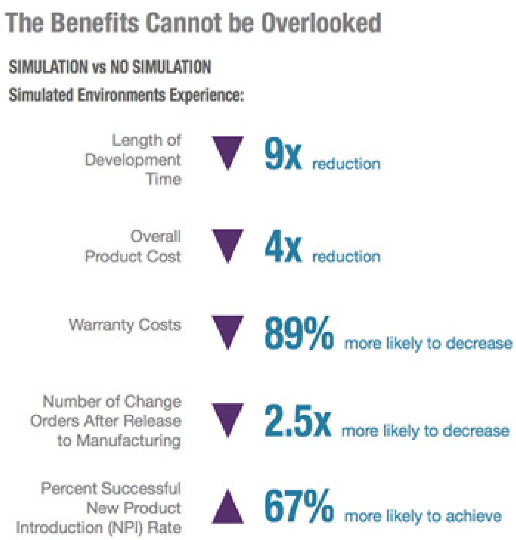
Companies are adopting IIoT solutions to increase productivity and improve the safety of their employees and machinery. The expanding adoption of autonomous operating systems and intelligent machines is helping to increase safety, but this must be done by developing equipment with much stricter requirements of precision and reliability. This is particularly true for communication latency and bandwidth, as well as embedded software control and operator display software. As an example, ANSYS helps the nuclear industry with embedded software development of instrumentation and control for reactor protection systems, human-systems interfacing, and control systems for other safety systems such as safety valves and backup diesel fuel auxiliary power engine systems.

Integration

Historically, industrial equipment designers have focused on thorough development of various components, with significant issues showing up due to increased system complexity when these components are assembled. This system- and subsystem-level integration effort often leads to over-design, cost-overruns, and even poor engineering choices in a valiant attempt to ship the product on time. In addition, the product development concepts in late stage validation and verification "make and break it" scenarios are giving way to "model and make it." ANSYS solutions for Model-Based System Engineering, Model-Based Software Engineering, 3-D Physical Simulation, and Multiphysics and System Simulation are helping organizations shrink their product development time. Scott Parent, previously VP of Technology at Baker Hughes said in the 2013 Oil and Gas issue of ANSYS Advantage, "identifying and resolving issues early in the process help us to mitigate risk, save millions of dollars, reduce development time and drive customer value."

Durability

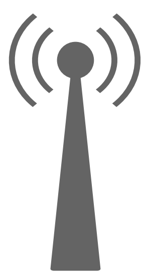
One of the attractions of IoT is that trillions of sensors and communication systems will be deployed to collect and share useful information 24 hours a day, seven days a week. These systems will be expected to perform reliably not just in their intended operating environment, but must also be able to withstand the rigors of usage in what are often extremely harsh environments whose exact conditions are difficult to define in advance. An integrated approach can lead to more reliable products. For example, consider the operation of industrial robots where both the motion and the operating conditions create thermal and mechanical stress in the equipment and the onboard sensors and electronics. ANSYS solutions can model at least three subsystems in a robotic arm system, including the power electronics used to power actuators (servos) that drive the arm's motion, the control subsystem that ensures the arm moves as required, and the assembly of rigid bodies linked by joints.



ANSYS: The Value of a Consolidated Simulation Platform

The increased difficulty of overcoming the core engineering challenges created by the complexities of making products IoT-ready is highlighting weaknesses in existing design processes. Independent research has shown that successful development of these products requires an increase in communication and collaboration between functional engineering teams. Without this, product delays, reliability issues, and cost overruns are likely. A product made without collaboration can lead to integration issues, especially when subsystems are built and over-designed because each team added their own safety margins.

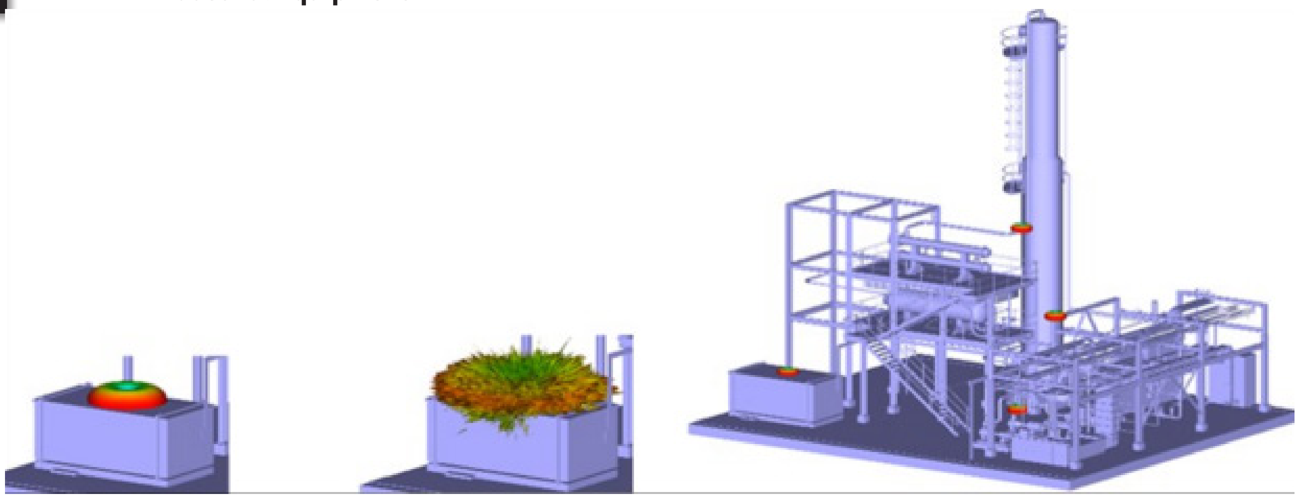
Companies with a strong culture of collaboration are leapfrogging their competition through the use of engineering simulation. Best-in-class companies use a consolidated simulation platform to analyze component and system-level behavior, as well as subsystem interactions, before physical prototyping. Designers at these companies are able to quickly explore the performance of numerous design alternatives. This allows them to optimize the design for cost, quality or performance. The metrics below highlight just some of the benefits of a simulation-based design approach executed on a consolidated platform that enables cross-functional engineering interaction.



Antenna Design and Placement

The performance of wireless systems can be very different in the real world when compared with the prototype testing environment of an anechoic chamber. When antennas are installed in the industrial environment, their performance will be impacted by the location of other antennas as well as other structures. Multipath signal propagation and fading are just some of the issues created by complex real-world structures, mobility, and even humans. Additionally, modern devices use multiple wireless technologies and frequency bands, requiring multiple antennas. As a result, antenna coupling and co-site issues can degrade performance.

For a typical example, consider the multiple devices with antennas installed in a plant. Proliferation of antennas in a complex industrial environment creates reliability issues. In the example depicted in the figure below, ANSYS' integrated antenna design technology using shooting and bouncing ray simulation techniques was used to identify and help prevent antenna 'co-site' problems.



Model and simulation results courtesy of ESSS

Chip-Package-System Design

Industrial equipment integration into the IIoT requires access to reliable, high speed and precise communication and control enabled by devices that have printed circuit boards (PCBs) and/or semiconductor integrated circuits (ICs). Whether designing or integrating a PCB or an IC, engineers must balance the requirements of three broad areas that affect product reliability — electrical, thermal and mechanical performance.

The chip-package-system workflow, unique to ANSYS, enables engineers to improve electronic system performance. The workflow enables PCB designers to simulate their designs while including crucial information from IC and package models. Conversely, the workflow allows IC designers to include the impact of package and PCB when verifying their IC designs. With all relevant system-level considerations modeled and simulated, engineers can reduce electromagnetic interference, increase electrostatic discharge (ESD) protection, and improve the electronic systems to develop the intelligence and controls that power the IIoT.

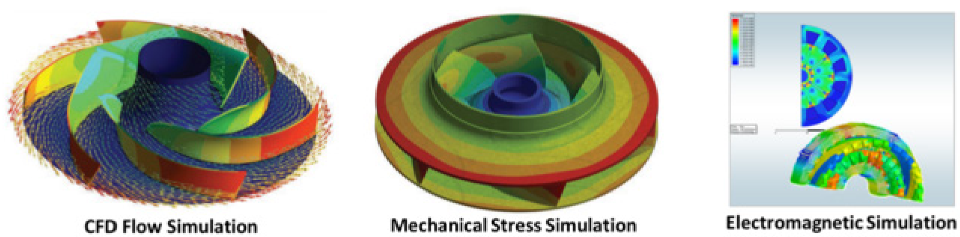
Power Management

Anyone whose smartphone battery has run out understands the essential role of power management. But power management isn't just about smartphones or Wi-Fi. Energy harvesting, wireless power transfer, and low power IC design are the foundations on which many IoT devices will be built. ANSYS solutions help engineers design more power-efficient electronic devices, and also solve power requirements of a different sort. There are estimates that pumps account for 10 percent of world electricity usage. Engineers at Grundfos Pumps use ANSYS solutions for optimizing pump performance and predicting and reducing electromagnetic-induced vibrations and noise from electric motors. Selected images from CFD, structural and EMag calculations of a pump and motor performed to increase pump efficiency and reduce motor acoustic noise are shown below.

Sensors and MEMS

Many aspects of control and automation rely on sensors. The advancements in sensor technology drive sensor-based decision making. Similarly, microelectromechanical Systems (MEMS) play a pivotal role in incorporating automation, asset tracking, conditional and damage monitoring systems, and building of smart factories. ANSYS has a long history of working with MEMS designers, enabling its customers to deliver better MEMS products. For example, engineers at SilMach used ANSYS to create electromagnetic actuators that were 100x more efficient than the previous standard version. Industrial equipment designers use ANSYS to better understand the placement and performance of sensors and MEMS in their equipment.

Reliable performance of sensors and MEMS can have substantial business impact on operations. Often it is not just the performance of a given piece of equipment, but the economic impact of that asset downstream and upstream of the point of impact. Consider the example of electric submersible pumps used to lift oil to the surface in many wells. A single pump failure can cost hundreds of thousands of dollars a day in lost production. A pump that is well-designed and appropriately instrumented for monitoring and control enables proactive maintenance, eliminating failure and the subsequent non-productive and costly delay affecting the production.



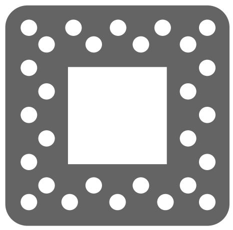
Pump simulations using ANSYS solutions. Courtesy Grundfos.

Support for Virtual System Prototyping

The interaction of the software, the electronics hardware, and the multi-domain nature of problems significantly increase the complexity of the engineering challenge. Simulation software from ANSYS can help by providing reliable simulation results that include systems-level qualities, properties, characteristics, functions, behavior and performance insight. Based on this high-level perspective, system designers can make informed design choices that optimize the performance of not only each individual component, but also the entire system.

One component of the ANSYS solution is SCADE Suite. In a case study related to systems responsible for safety functions for wind turbines, David Steele, a specialist and software analyst at Vestas, said in a video testimonial, "…SCADE Suite allows us to develop more advanced and complex features that our customers are asking for. That will allow us to present products that give a better cost of energy and with a lower lost production factor, as we call it. That will allow us to give our customers a better value. This means that we can have a greater advantage over our competitors."

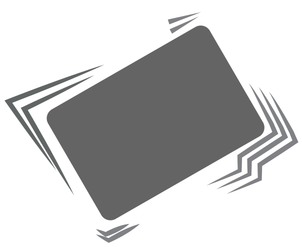
Embedded Software



An enormous amount of embedded intelligence resides in industrial equipment,assets and devices already deployed. Advanced controllers for safety and production automation have been a main focus for many years, and will continue to advance even faster with ongoing focus on the industrial internet. The continuing evaluation of intelligent machines and integration of smart devices means embedded software will play a stronger role in performance enhancement and control of industrial equipment.

Industrial equipment and energy companies use ANSYS SCADE for embedded software application development, embedded controls and displays in high-dependability mission- or safety-critical applications (with or without software certification requirements). For example, Capstone Turbine used SCADE to develop the software for a microturbine generator system. In general, SCADE's economic benefits include overall 50 percent reduction on development and V&V cost of embedded software development by a) automatic production of 80 to 90 percent of the application software and related documentation, b) suppression of code reviews and c) 80 percent low-level testing cost reduction due to certification of automatic code generators.

Designing for Harsh Environments



Many industrial equipment and automation machines, industrial robots and autonomous mining machines/vehicles are subjected to impact, vibrations, extreme and fluctuating temperatures,electromagnetic interference, explosive gases, dusts, high humidity and corrosive chemicals.

The offshore oil and gas industry frequently deals with harsh environments. ANSYS customers in the energy industry develop equipment and machinery to work in offshore oil and gas fields; some also develop new concepts to generate electricity from ocean waves. Offshore companies are developing subsea power stations, production and processing equipment to produce subsea factories, where electronic equipment and control systems must be designed for reliability and minimal intervention. New classes of remotely operated vehicles (ROVs) and autonomous underwater vehicles (AUVs) perform construction, operation, maintenance, inspection and repair of subsea installations.

In many of the industrial applications mentioned, physical testing and prototyping is usually expensive and sometimes not feasible. Using complete virtual prototyping, ANSYS customers are able to certify the performance of their subsea equipment to meet regulatory and industry standards.

4. ABOUT ANSYS: Your Trusted Partner

Industrial equipment manufacturers, energy and process companies, power generation utilities, and metal and mining companies across the supply chain and around the world rely on ANSYS to develop products that meet their innovation, technical and business objectives. With a well-established track record of over 45 years of engineering analysis solutions, ANSYS will remain your trusted partner — delivering the proven simulation capabilities that more than 10,000 companies have come to rely on — as the industrial world embraces the IIoT.

References:

[1] https://www.bcgperspectives.com/content/articles/engineered_products_project_business_industry_40_future_productivity_growth_manufacturing_industries/?chapter=2

ANSYS, Inc.
Southpointe
2600 ANSYS Drive
Canonsburg, PA 15317
U.S.A.
724.746.3304
ansysinfo@ansys.com