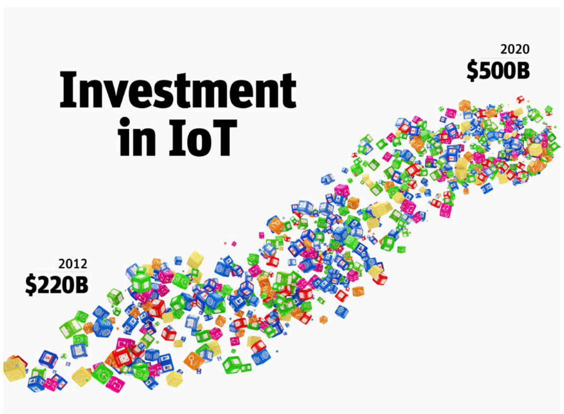
White Paper

# Engineering the Next Industrial Economy
# Industrial Internet of Things and Industry 4.0

The Industrial Internet of Things will improve industrial efficiency through Big Data analytics. But how will this happen quickly? It will require vast improvements in electronic systems to increase speed, optimize power consumption, reduce electromagnetic interference, and ensure physical as well as software reliability and security. The complexity of this task is enormous and can only be overcome with engineering simulation.



Investment in the IIoT is exploding.

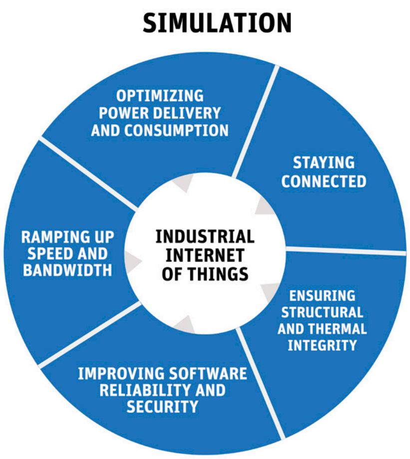
Today we live in a world based on connectivity and communication, in which a burgeoning network of electronic systems and devices helps us navigate our days.

While smartphones, tablets and wearable electronics are very visible in our lives, a larger revolution is taking shape in the industrial arena. Industry leaders are racing to benefit from the Industrial Internet of Things (IIoT) (or Industry 4.0) mega trend, and, are increasing investments from $20B in 2012 to an estimated $500B by 2020. They are expecting to capitalize on the estimated $1.7 trillion in cumulative net value of the IIoT. [1]

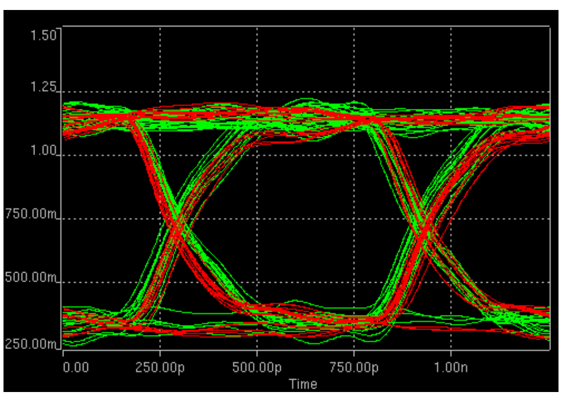
Among many ambitious goals, the Industrial Internet initiative aims to improve industrial efficiency through the use of Big Data analytics. By collecting vast amounts of data through networks of sophisticated sensors, the architects expect to improve product reliability, increase factory utilization and deliver greater decision-making insights. Every industry will benefit. For example, industrial equipment operators will be able to perform predictive maintenance; hospitals will utilize integrated systems to improve patient care and outcomes; and cities will use real-time data to optimize traffic patterns, improve the delivery of civil services and reduce pollution.

**Big Opportunity, Big Challenges**

While the Industrial Internet represents a big opportunity, there are significant challenges. Industrial Internet systems must not only be innovative and high-performing, but also extremely reliable and affordable.
How can engineering teams manage these pressures? For at least four decades, market leaders have relied on simulation-driven product development to launch their products quickly, cost-effectively, and with a high degree of confidence that they will perform as expected in the real world. Designing robust systems for the Industrial Internet will require engineers to improve wireless communication speed and reliability, increase energy efficiency, optimize wireless system performance, ensure structural and thermal integrity, and improve software integrity and security. The following sections provide greater insight into these challenges as well as some technical examples.




A wide range of challenges to the development of the IIoT can be overcome with engineering simulation.




Ensuring reliable high-speed communication requires signal- and power-integrity analysis on DDR IO



### Ramping Up Speed and Bandwidth

Smart cities, autonomous vehicles and utilities will all demand real-time data for decision making. For example, the electronic content in automobiles is expected to increase 6.5 percent annually between 2014 and 2019 — faster than many consumer categories.[2] Command, control and communication technologies are going to be crucial, and require high-speed networking infrastructure — servers, routers and switches. Designing high-speed printed circuit boards (PCBs) and semiconductor integrated circuits (ICs) poses significant challenges for these applications due to design complexity and high reliability requirements.

Whether designing a PCB or an IC, engineers must balance the requirements of three broad areas that affect product reliability — electrical, thermal and mechanical performance. Engineers also need to simulate the interactions between the semiconductor die or the IC, the IC package and the PCB.

Ensuring electrical reliability requires power- and signal-integrity analysis to minimize crosstalk and increase design robustness. Addressing thermal reliability calls for simulation to evaluate the impact of temperatures of the board and associated components, ensuring that the devices operate reliably across the specified operating range. And mechanical reliability requires a thermal–stress simulation to evaluate thermal and mechanical stresses in the board along with solder joints between board and components.

In addition to performing individual physics simulations, engineers must consider the interaction between physics disciplines, coupling signal integrity analysis with thermal simulations and connecting thermal simulations with structural analysis. This method provides a holistic view of the overall reliability of PCB design.

Engineers can use ANSYS RedHawk, ANSYS Totem, ANSYS SIwave, ANSYS Icepak and ANSYS Mechanical to implement a chip-package-system (CPS) workflow that improves electronic system performance. The workflow offers an efficient way to simulate a chip-aware package/PCB system, as well as design PCB- or package-aware ICs. The workflow enables engineers to reduce sources of electromagnetic interference (EMI), improve electrostatic discharge (ESD) protection, and design the robust PCBs/ICs that power our high-speed, cloud-computing world.

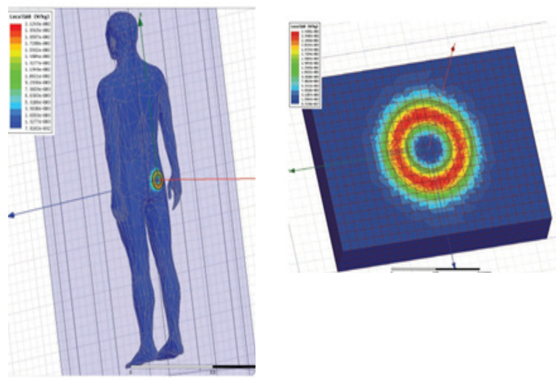
### Optimizing Power Delivery and Consumption

With billions of devices dependent on energy, optimizing power delivery and consumption is crucial for the Industrial Internet. A secure and smart energy grid will require millions of sensors to make informed decisions and communicate them in a timely fashion. Implanted medical devices and autonomous vehicles will also require energy-efficient sensors and systems. Engineers can use ANSYS Maxwell to design wireless power-charging and energy-harvesting technologies that will be utilized in many of these systems.

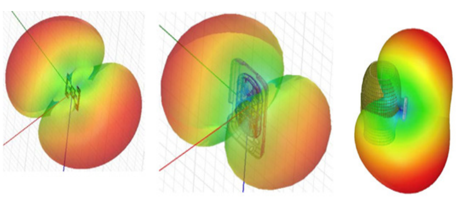
# Charged Up

Medtronic ensures the safety of recharging subcutaneous medical devices through simulation.

**ansys.com/charged-up**

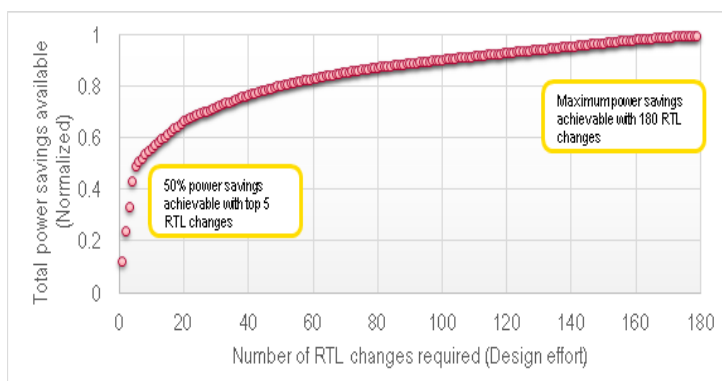


Engineers at Medtronic used ANSYS Maxwell simulation to determine that the recharging system for a new product produced levels of exposure far below the limit specified in the regulation.



Optimizing a cell phone antenna using simulation in free space, in enclosure and with human body model. Courtesy Vortis.

Because integrated circuits (ICs) are at the heart of our electronics revolution, engineers must pay close attention to IC design. Low-power IC design begins with optimization of the Verilog and VHDL code, also referred to as register transfer level or RTL. By making simple changes to their RTL code, engineers can significantly reduce chip power consumption. But with the ever-increasing number of logic elements inside each IC, performing this level of optimization is a daunting task. Design automation tools like ANSYS PowerArtist are ideally suited to quickly identify the key RTL changes with the greatest power-saving potential.




It is vital to identify RTL changes that have the greatest power-saving potential.

# More Gain, Less Pain

Using simulation, Vortis can design a more efficient wireless antenna in up to 90 percent less time.

**ansys.com/gain**

Power efficiency isn't limited to the design of ICs. To achieve the best power and performance trade-offs, engineers need to consider the whole system, including antenna and wireless systems. An optimized antenna system can provide increased communication range and longer battery life. For example, simulation allows engineers to model the performance of antennas in free-space, within a device enclosure, and then next to the human head. Vortis Technology has determined that properly designed antennas can provide 125 percent more battery life and Synapse has reported 5 times the performance of a standard antenna.

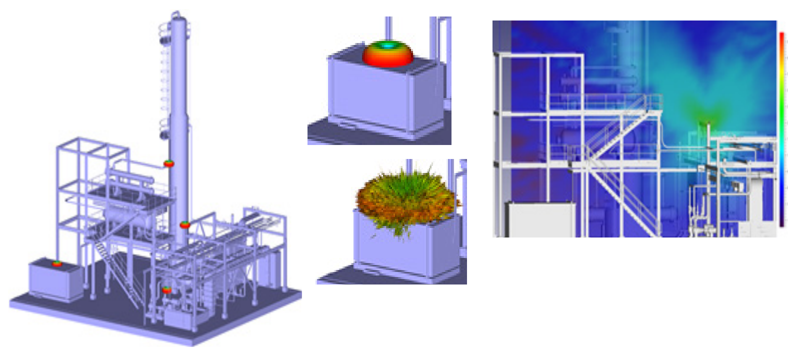
*"Using ANSYS RedHawk and ANSYS Q3D Extractor, NXP engineers designed a new IC chip for a digital automobile radio with a 75 percent footprint reduction, lower costs and superior sound quality."*

— **Jacob Bakker**
*Consultant Physical Verification, NXP Semiconductors N.V.*

## Staying Connected

To take full advantage of the Industrial Internet, wireless sensors and networks will be deployed within modern factories and transportation systems. But this environment presents a challenge for wireless connectivity. The wireless performance of antennas can be very different when installed in an industrial setting or a vehicle, when compared with the prototype testing environment of an anechoic chamber. Antenna coupling, multipath signal propagation and fading are just some of the issues created by the presence of other antennas, complex industrial structure geometries and mobility. All these factors conspire to degrade the communication environment.

For example, when a wireless sensor network is deployed in a factory, each sensor uses a dipole antenna to communicate with other sensors. The ideal radiation pattern of a dipole antenna resembles a donut, but, when deployed in an industrial setting the complex industrial structures distort the radiation pattern, reducing antenna efficiency and leading to unreliable performance and failures.



The ideal donut-shaped radiation pattern of a sensor is disturbed in an industrial setting due to structural and antenna co-site issues. Engineering simulation can identify and mitigate these issues. *Courtesy ESSS.*

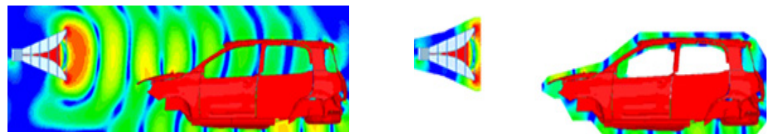
So, how can engineers ensure reliable wireless connectivity within an industrial setting, or on a car, plane or ship without having to resort to time-consuming build-and-test methodology?

Using ANSYS Savant and ANSYS HFSS, engineers can perform a near-field analysis to mitigate the effects of the entire industrial environment on the performance of antennas and wireless devices. The finite element (FEM) domain decomposition, 3-D method of moments (MoM), hybrid FEM–MoM, and shooting and bouncing ray (SBR) techniques can also be used to quickly solve electrically large and complex full-wave electromagnetic models. This virtual prototyping approach provides greater insight, improves accuracy and increases reliability.

## Test Drive for EMI

Automotive electromagnetic interference and compatibility can be determined more efficiently using new technology within ANSYS HFSS.

**ansys.com/test-drive**



The electric field on both the surface shell and a plane that bisects the solution volume of the vehicle for traditional FEM (left) and FE-BI (right) results. Courtesy ESSS and Fiat Chrysler Latin America.

### Ensuring Structural and Thermal Integrity

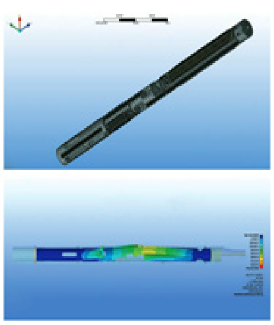
Today, high-tech companies turn to advanced lightweight, yet strong, materials to create flexible electronics. However, a range of complex issues must be considered when evaluating new materials — including electrical conduction properties, structural strength, dimensional stability over time and resistance to thermal build-up. Design for manufacturability is also an important consideration.

Embedded electronic systems in the industrial environment must endure harsh operating conditions, such as the noisy factory floor or a hot down-hole environment in the energy industry. Even with the strongest practical materials, devices are damaged by impact or heat. To achieve the right trade-offs between material strength, cost and design elements, engineers can turn to ANSYS structural, fluids, and thermal simulation solutions.

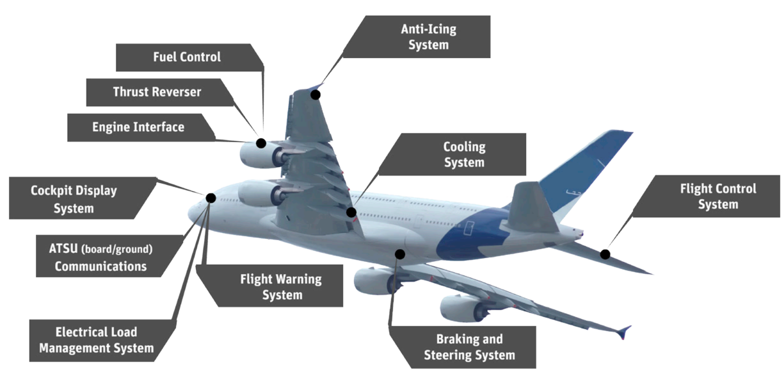
Electronic device drop tests are performed to ensure reliability of electronic devices under adverse conditions.

### Improving Software Reliability and Security

Software is key to fully realizing the value of the Industrial Internet. Big Data analytics will be used to predict events and prescribe remedies before failure happens. Autonomous vehicles, unmanned aircraft and factory robots, for example, will rely on connected sensors and software to operate safely. The Airbus A350, for instance, contains nearly 6,000 sensors, generating over 2.5 terabytes of data per day, while the next generation Airbus 380 will be equipped with nearly 20,000 sensors, generating even more data. To fully characterize how the complete product will operate, leverage the insights from the sensor data and make real-time decisions, sophisticated software is needed.



Baker Hughes simulates tools and components in a down-hole environment to improve survivability of printed circuit board assemblies.




Engineering simulation is crucial to understanding and designing complex safety-critical software and systems.

With so much riding on software, data security and integrity are major concerns. ANSYS SCADE Suite can be used to model complex systems, understand the interaction of various subsystems, and generate high-integrity software code that complies with many industry standards. The ability to generate millions of lines of code at the push of a button not only removes human coding errors, but also increases productivity, quality and traceability of code. Moreover, this capability shifts engineering effort from code to system, further improving engineering productivity, innovation and end-product robustness.

**Internet of Things**

ansys.com/IoT

### Investing in the Future

Since the earliest days of the high-tech revolution, simulation-driven product development has been a critical strategy for speeding innovation and improving reliability. In the connected economy of the Industrial Internet, engineering simulation continues to help hundreds of high-tech companies launch game-changing designs quickly, cost-effectively and confidently, creating market leadership and building some of the industry's strongest brands.

To learn more, visit ansys.com/IoT.

### References

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