The world was once defined by physical things, then a digital world emerged. Today, it is both. In the physical world, products, equipment and environments are functional and resolute.

They serve to extend the human form increasing our strength and abilities, helping us to be more productive in the settings that compose the world around us. In the digital world, software, data, and networks are helping us gather and communicate information. Insights are being captured and analysed in new and unimaginable ways, extending our thoughts, creativity, and understanding of the physical world. Fast and flexible, digital information defines and connects us to the world over time and space. These once independent forces have become interdependent and complementary, embodying the yin-yang concept. Just as hot and cold, day and night, and liquid and solid make two parts of a whole, we now live in a world that is both physical and digital at the same time. Ripe within that intersection is a new frontier for innovation, and the leading companies are creating competitive advantage from that opportunity.

Companies like Google and Microsoft which began as digital, are moving to create physical products, while large scale industrial companies like GE and ABB are reinventing themselves as digital. Long established businesses are being disrupted and surprising new markets are being created through the power of what’s possible within this new order. The speed of innovation is accelerating and now is the time to seize the opportunity.

For much of the past, the digital and physical worlds have been diverging, siloed in their experiences, formats, and interaction methods. We do things differently in the physical and digital worlds, even when our reliance on both worlds continues to increase unabated.
The Frontier of Innovation

New examples of this physical and digital convergence are now inherent to our time, and quickly claiming their place as the enablers of the next wave of innovation. As they do, they are changing not only the nature of products and how they are made, but the processes and outcomes that people and companies use them to achieve.

Convergent technologies that bridge the physical/digital gap:

- **IoT and Analytics** instrument the “things” in the physical world with software and sensors that connect these “things” directly to networks. This creates new capabilities to monitor, control, optimize and automate physical things through the data they generate, ushering in a new era of competition.

- **3D Printing** translates digital CAD models directly into physical parts and products to speed innovation and avoid costly intermediary processes. These additive manufacturing capabilities are also enabling entirely new product designs with features and structures not possible with traditional manufacturing processes.

- **Smart Manufacturing/Industrie 4.0** facilitates a closed-loop, real time Digital Thread that connects people, systems, and heterogeneous equipment inside factories. This creates a pathway to optimize manufacturing processes, and improve quality, visibility, and output.

- **Augmented and Virtual Reality** superimposes digital information into the user’s view of the physical world or a simulation of it. Delivering these digital insights in the context of a physical environment enables users to make better decisions, faster.
The implicit value of these technologies is two-fold. First, in their strong, inter-disciplinary connections. For example, IoT generates data about any thing in the physical world, while Augmented Reality superimposes that data back onto the physical world for humans to understand in context. Second, in their ability to ease the friction within the physical and digital dichotomy. For instance, 3D Printing translates the digital definition of any thing directly from the digital world into a physical part or product. Pursuing one of these opportunities alone brings value, but together they enhance the value of each.

Factory

3D design tools have enabled engineers to visualize and simulate a physical product digitally, revolutionizing the way they imagine and create. In the factory, products enter the manufacturing process as CAD models and PLM data that define them. But using additive manufacturing or 3D printing, this digital CAD and PLM data can easily be translated directly into physical parts or products to bridge the product from concept to creation. This creates efficiency across the organization especially in product design and engineering, where it adds agility in the design process while reducing the need for iterative physical prototyping. By modelling the physical parts digitally and leveraging algorithms to simulate and optimize designs, parts and products can be built stronger and more efficiently while reducing the materials required. Without a robust digital definition and design, optimized with simulation and analytics software, none of this would be possible.

Assessing the Opportunity at Hand

These technologies at the frontier of innovation are driving the transformation not only of the products and services they enable, but the outcomes of processes those products and services are used for in the environments where we work and live:

Global manufacturing giant GE has ramped up their commitment to 3D printing technology, pledging to invest $1b by 2020. They predict to return $3-5b in costs over the next 10 years as a result, saving in design, engineering, and manufacturing processes. Using digital strengths of analytics and simulation, they are designing parts that are stronger and use fewer materials, reducing scrap while improving quality. Integrated across their connected operations, insights from the physical world are driven up and downstream across the factory and back-office to improve visibility and identify opportunities for further improvement. Bringing digital simulation and analytical capabilities into the production environment and returning physical data back from the factory, GE is capitalizing on the opportunity offered by the physical and digital convergence.
We stand at the frontier of a new age of innovation, where the industrial revolution is colliding head on with the digital revolution.”

– Jim Heppelmann
CEO, PTC

Shell: Connected worksites improving operations throughout

At Shell, they are embedding sensors across their worksite environments. This new data and the insights they generate about the physical world are being gathered and analysed to optimize the performance of their semi-automated systems. The interplay of these physical assets can be simulated digitally to optimize production and predict costly machine failures using a digital twin. To deliver these actionable insights, workers are becoming increasingly connected with mobile interfaces and connected fleets. These smart technologies have made their way downstream as well to improve refinery and distribution processes in addition to informing back-office operations. The key for Shell is in the combination of these technologies to enhance their operations. “Smart Fields is about integrating people, processes and technology,” said Joseph Low, a senior engineer at Shell. Bringing the communication capabilities of the digital world into their worksites to harmonize the relationship between people and machines, Shell is embracing the physical and digital convergence with their Smart Field initiative.
Cities
Across the globe, governments are pursuing Smart Cities initiatives that incorporate digital technology into the streets, infrastructure, and public services that citizens and businesses rely on. Many of these initiatives start in silos, from connecting the public transportation fleet, to tourism, where digital experiences are delivered using location data and augmented reality to showcase the city’s history, to energy management systems that save power and optimize the grid.

Singapore: Centralizing operations for the smarter city
The city of Singapore seeks to be the world’s first truly smart city, centralizing these initiatives rather than operating in siloed projects. This bold initiative, called Smart Nation³, has Singapore creating a Digital Twin of the entire city in efforts to connect and enhance the health services, day-to-day living, transportation, and other public services that they offer. This Digital Twin is achieved using a combination of mobile apps, sensor-connected public infrastructure, and video cameras streamed and analyzed by computer vision. This data is combined, and simulation tools analyze the full footprint of information about the city. This Digital Twin will be used to improve life in Singapore in ways such as rerouting buses based on traffic, anticipating how new construction may affect the strength of network signals, or understanding the way disease spreads to aid in crisis prevention. Using the analytical and real-time communication offered by the digital world, the city of Singapore is leveraging the physical and digital convergence to enhance the lives of its citizens.

Logistics
Outside, companies are leveraging boundary-crossing technologies like Augmented Reality and Wearables to improve speed, efficiency, and accuracy in logistics and transportation of goods and services. Bringing the right digital information to workers about their physical environment, the movement of goods, and needs of customers enables them to optimize their activities for new gains in productivity.

DHL: Competitive advantage gained through AR-informed processes
DHL has a vision is to be the logistics company for the world. To achieve that, they have deployed augmented reality systems that track and manage picking and packing lists for warehouse employees. Using wearable ring scanners, workers capture their ‘pick’ item information at the warehouse, automatically quality checking it digitally to verify accuracy and track the movement of goods. While Augmented Reality is helping DHL capitalize on the physical and digital convergence, “Testing technologies like augmented reality, robotics and internet of Things will continue to be a big part of our DNA,” according to John Gilbert, DHL CEO, Supply Chain⁴. Making workers more productive in the physical world by empowering them with contextually aware digital experiences, DHL is creating a competitive advantage with the physical and digital convergence.
Smart, Connected Products

While the value in these environments is clear, the implications are significant for the makers of things that operate in these environments – the innovative Manufacturers bold enough to lead this transformation. Strategies to capitalize on the physical and digital convergence must be adapted to individual businesses and may require new competencies, evolving business models, and a reimagining of where value can be created today and in the future.

CAT: Strategically capitalizing on smart manufacturing

For manufacturers, digital capabilities can not only optimize their business processes, but differentiate their products and deliver key customer insights that open the doors for new services. CAT, a heavy equipment company in the industrial space, is actively pursuing an IoT and analytics strategy by bringing these boundary-crossing technologies to its portfolio of products. Their “Age of Smart Iron” initiative positions digital technology as a key differentiator and source of data for customers to capitalize on. Combined with Augmented Reality experiences to offer this new data, CAT customers and service providers can understand critical product performance data to reduce downtime. CAT also offers productivity solutions for customers to perform work more efficiently with higher accuracy. One of CAT’s customers saw a 67% reduction in fuel consumption, as well as over a $200,000 savings in labour costs because a project was completed 2 months ahead of schedule thanks to these technologies. CAT already has over 400,000 smart, connected products deployed worldwide and actively growing its installed base in these product categories.

PTC – Pioneers of Innovation

For over 30 years, PTC has driven new vision for business, pioneering the tools that have powered hundreds of thousands of companies around the world. First to imagine and develop a 3D CAD digital mock-up tool to capture the essence of a physical product, first with the ability to deliver the 3D data for prototype development to 3D printers, and PTC was first again to understand the value of web-based PLM to unlock the possibility of Global Product Development. PTC is leading the industry yet again by being first to connect PLM and IoT, and marrying IoT and AR. PTC’s portfolio represents a unique combination of technologies that make the physical and digital convergence a reality, claiming dominant positions in recent competitive assessments by IT industry analysts IDC and Forrester.

We stand at the frontier of a new age of innovation, where the industrial revolution is colliding head-on with the digital revolution. The gains of each are reinforcing and amplifying each other, and what we’ll do together with our customers and partners will continue to transform the world as we know it.