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White Paper

Smart factories in the aerospace & defense industry

How robotics, AI and other emerging technologies can help manufacturers build better platforms faster, cheaper and safer

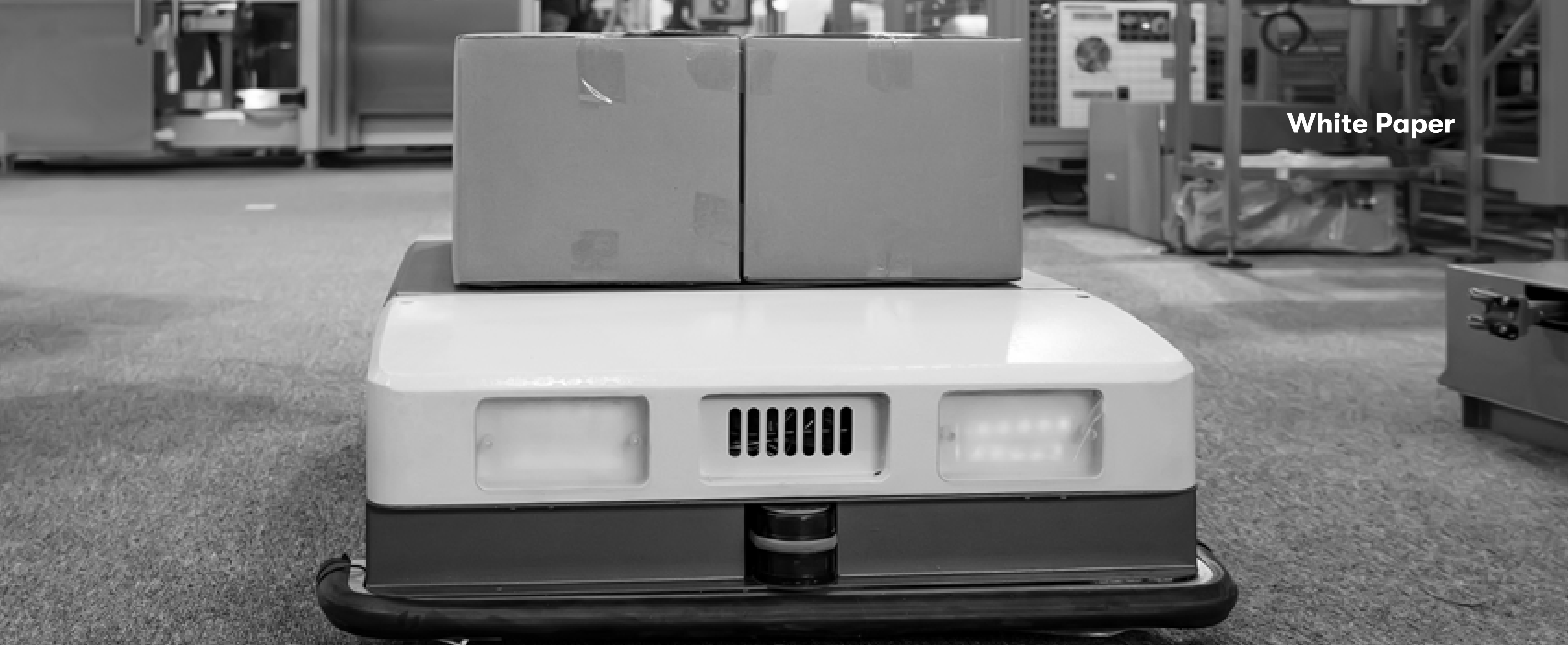
Whether we like it or not, robotics, artificial intelligence (AI) and automation are here to stay. The good news is that these emerging technologies are now supporting smart factories — manufacturing facilities that are more efficient and effective than ever before. Smart factories can actually create more jobs than they remove, lower costs and generate more revenue. They reduce injuries and fatalities, and at the same time increase output, quality and consistency. In aerospace and defense, where quality and precision are critical, smart factories are an essential investment for higher mobility (speed and maneuverability), lethality (ordnance velocity, range and damage) and survivability (resistance to damage).

Smart factories can pave the way for spectacular cost and time savings. Harley-Davidson's smart factory, for example, cut a fixed 21-day production cycle down to 6 hours and slashed operating costs by $200 million.

However, it is not all about saving money. Smart factories can also enhance quality and employee satisfaction. Focusing experts on higher-value work and delegating repeatable tasks to technology means those experts can spend their time improving products instead of making sure they are built correctly. And yes, AI, robots/cobots, drones and the like may make specific human roles obsolete. However, they will create new ones. Individuals who had been carrying out a task that a robot can now do will find new tasks that need to be done: maintaining the robots or coordinating the drones, or managing the AI infrastructure, and more. These kinds of skill shifts are happening everywhere.

Skill shifting in smart factories is one of the most significant outcomes of digital transformation, and many are convinced that these technologies will create many additional jobs. The World Economic Forum in 2018 estimated that AI and robotics, for example, will create 60 million more jobs than they destroy. While more individuals will be needed to support these new technologies, throughput and product quality will be significantly increased, which could offset the cost of this headcount.

What is a smart factory? That depends on whom you ask. Implementations range from tablets that provision edge computing all the way to humanless factories. With so much variance, where does an organization start on its Manufacturing 4.0 journey? To help guide you, we look at the potential capabilities of a smart factory, the technologies at the center of these capabilities and how to tackle the age-old question, “How much is enough?”



The art of the possible

Various technologies support today's smart factory and hint at what's possible in the near future.

Smart forklifts. Moving "stuff" around a factory has been pivotal to manufacturing since Richard Arkwright[1] started spinning cotton on a water frame in 1769. Although most large manufacturing facilities now have conveyor belts to transport products and materials, they still need forklifts. With the aid of the internet of things (IoT) and radio frequency identification (RFID) tags, human-controlled forklifts can now be replaced with AI-powered variants that are more efficient and less prone to accidents from fatigue and other human factors.

Smart carts (self-routing assembly lines). The assembly line revolutionized industry and is considered one of the key advancements defining Industry 2.0. The Ford Motor Company first used it successfully in 1913 after employee William Klann visited a slaughterhouse and saw single individuals repeatedly "disassembling" the same part of an animal carcass. He suggested that a single individual could also assemble the same part of a car — giving rise to the idea of bringing the product to the worker.[2] Although that concept hasn't changed, the way in which we bring the product to the worker is now being reinvented.

The traditional assembly line implies that all vehicles are made the same, but today's platform often has multiple variants. This is certainly the case with the family car, and it is fast becoming a requirement for military platforms, as deployment conditions and applications can vary significantly. Platform variance has led to modular design and manufacturing, where different areas of a factory are dedicated to building specific modules. With the rapid evolution of AI, smart carts can safely and intelligently transport vehicles to these areas. Audi is currently reaping the benefits of the concept in its new European smart factory[3], so the idea is not as far-fetched as it may sound.

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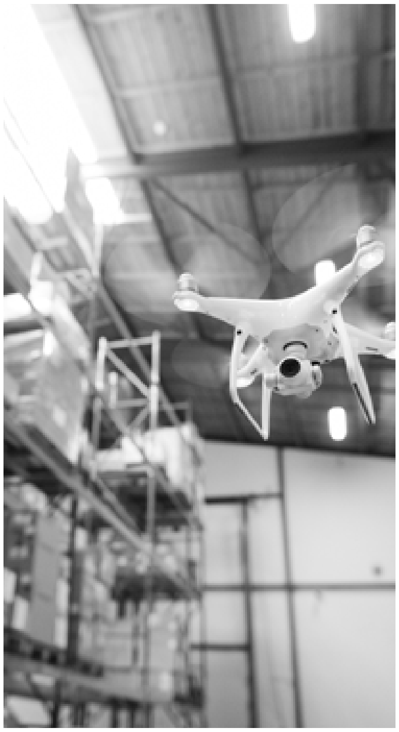
[1]https://en.wikipedia.org/wiki/Richard_Arkwright

[2]"Henry Ford Sponsors Improvements in the Automotive Assembly Line," Jeremy Norman's HistoryofInformation.com, http://www.historyofinformation.com/detail.php?id=3127

[3]https://www.audi.com/en/experience-audi/mobility-and-trends/digitalization/e-tron-production.html



Drones. Believe it or not, drones are now a legitimate option for building resilience into factory parts distribution and avoiding unplanned breaks in production. Air redundancy through carrier drones addresses the very real possibility of tech glitches, power problems and other issues interfering with ground vehicles' ability to distribute parts.

Cobots. Robots have significantly improved the output, quality and safety of manufacturing in the last two decades. However, even fully autonomous robots have limitations, including human exclusion zones, space requirements and lack of task flexibility. Robots are great for large and highly repeatable tasks, such as welding, but if parameters change, they need to be reprogrammed and potentially repositioned. That is where cobots — collaborative robots that interact with and assist humans — can play an important role. Cobots are effective with smaller, complex tasks, such as handling and positioning small parts, where a human can control the pace and complexity.

Additive manufacturing. Best known as 3D printing, additive manufacturing can create parts, jigs, templates and pretty much anything else that can be digitally designed and loaded onto a printer. Technology advancements mean that plastic is no longer the only possible medium and that much larger printers can create larger components. Today a number of additive manufacturing platforms create metallic parts for military applications. One technology even rams particles of metal together at high velocity to create the fusion required to print a part.

Additive manufacturing enables the same assembly to be produced as a single, monolithic part — both in metal and plastic. This can remove significant weight from a platform — in nonarmor components, for example — enhancing mobility and reducing the amount of material without compromising overall strength.

Digital twin. No smart factory is complete without a digital twin — a digital duplication of a physical twin. For example, a 3D model as a digital twin can simulate the dynamics and characteristics of a tank's physical diesel engine to predict potential problems before the engine is even built.

Digital twins have been around for some time; in fact, the National Aeronautics and Space Administration (NASA) has been using them for several decades. AI, high-performance computing and other recent advances have made digital twins far more valuable and have opened the door to twins that scale to an entire factory or even a city. A digital twin can bring significant value to a factory by:

- **Analyzing and optimizing the factory layout.** Vehicles, parts and anything that moves inside a factory can be tracked using IoT — essentially a collection of connected devices that share and process information — and the data can be fed into a digital twin of the factory. Analysis might reveal that most parts are delivered to a location far from the parts store, and that moving the function would save time and cost.
- **Identifying operational bottlenecks.** A twin can be used to analyze how long vehicles remain in different assembly areas of the factory and identify and rectify pain points.
- **Locating parts, vehicles and equipment.** As almost anything can be tracked inside a smart factory through IoT, the digital twin can be used to find items when needed.

Augmented reality (AR). Considered one of the most significant changes in the way we undertake daily tasks, AR could transform manufacturing almost by itself. The list of use cases that AR can improve is impressive. AR blends the physical and virtual worlds. Compared to VR, where you can't see the physical world when you are immersed, AR provides a digital overlay to the real world. Someone wearing an AR headset can quite easily walk around and not bang into things — important in a manufacturing environment. Here are a few examples of the operational efficiencies AR brings to a smart factory:

- **Employee inductions.** AR immersion can play an important role in facility familiarization and safety, making learning faster, easier and more effective than from a paper handout or a PC. The heightened visual context provides a fun way to learn and improves information recall.
- **Virtual over physical manufacturing.** AR offers immense value to engineering and manufacturing. Instead of looking at a drawing, assemblers can overlay a 2D or 3D model on the physical vehicle. They can also incorporate other smart functionality, such as interacting with an engineer via video, to resolve an issue.
- **Locating parts and materials.** Finding the right items at the right time is critical. If parts are not available, operations can slow down significantly and even stop. In a smart factory, workers can enter a part using an AR headset (or tablet) that navigates them to the correct location.

Technologies at the heart of a smart factory

A number of core technologies have advanced manufacturing to Industry 4.0, the fourth industrial revolution. Each capability is powerful in its own right. Used collaboratively, they move the needle and enable the next generation of technologies, including cobots, drones and smart vehicles. Here's a look at three core technologies.

Industrial internet of things (IIoT) harnesses the power of IoT, machine learning and big data to enhance industry-specific tasks, expedite decision making and improve operational efficiency and effectiveness. Network-connected sensors on tools and machinery can generate metrics — time on tools, yield, quality, throughput, schedule, downtime and capacity utilization — that help identify bottlenecks. For example, discovering how long it takes a human to fasten a certain assembly to an armored vehicle may prompt a switch to cobots or robots for the task. The security of IoT is also a critical component to scale out the environment. Security architecture could enable tablet single sign-on using contactless cards and facial recognition. But increased security and configuration management for machine programmable logic controllers (PLCs) and IoT devices and control system networks is required.

AI and machine learning are closely associated with each other and fall under "smart" technology — a computer system able to perform tasks that normally require human intelligence, such as visual perception, speech recognition, decision making and language translation. AI — the science of making machines smart enough to perform tasks by themselves — has been developing over several decades. Machine learning — giving machines access to data and letting them learn for themselves — is slightly newer.

It is the decision-making element of AI that makes it so suitable to the smart factory, which depends on data analysis and rapid decisions based on that analysis to expedite, and therefore increase, a factory's output and quality. AI is considered the Swiss army knife of a smart factory, as it can increase the effectiveness of nearly every technology layer in that environment.

High-performance computing (HPC), often called "big compute," is literally that — computing on a big scale. HPC provides more computing power (typically server-side resources) to get things done faster. What you could do in a day on a desktop can be done in minutes through HPC.

HPC is particularly valuable for complex scenario simulations or high-end graphics in digital design and VR. Emerging and evolving technologies also benefit from HPC — with AI, for example, the more compute power you can throw at it, the quicker and smarter it becomes.

A smart factory aims to address operational efficiency and effectiveness so things can get done safer, faster and smarter. HPC is all about faster, and it can have a dramatic impact on cost and schedules — and thereby provide an easy-to-define, tangible benefit to a factory's operations.

How much is enough when it comes to a smart factory?

How much technology is enough? The answer is not one-size-fits-all. Technology is very specific to the organization: the maturity of its processes, culture and technology; and the outcomes it wants to achieve. There is, however, a very simple — albeit stakeholder-intensive — way to understand where to draw the line. It relies on one of the most fundamental and important artifacts an organization should own: a business capability model.

A well-developed business capability model provides detailed insight into how your organization does business. It identifies all the capabilities an organization uses to deliver output and ties every capability to an owner. This is not just a finger-in-the-air exercise; it requires careful analysis of the people, processes and technology for each capability.

Once a valid and up-to-date capability model exists, it is easy to carve out the top 10 capabilities. In the chart, we have identified five typical capabilities and rated them on their current and desired maturity levels. (A future-state goal might be based on your desired maturity level or on the need to mobilize a new program or product to meet customer requirements.) (**See Figure 1**)

Capability	Current Maturity	Desired Maturity	People	Process	Technology
Safety, Health and Environment	8	10			√
Quality Control	7	10		√	√
Product Life-Cycle Management	5	8	√		√
Subtractive Manufacturing	7	9		√	
Parts and Material Management	3	9	√	√	√

Figure 1. Example of the business capability model

The final step in the "How much?" process is to understand what issues across the three areas — people, process, technology — affect the capability's current maturity. If there is a tick in the technology box, the next step is to determine how a certain technology uplift could help improve that area. If you cannot define any real technology gaps for a capability, you can draw a line around further investment. For example, if a handheld tablet can deliver the same capability as an AR headset, there is no point in making an incremental investment in AR.

Smart factories — not an illusion

Ten years ago, smart factories were considered science experiments and a waste of research and development cash. However, without those "science experiments," we would not be where we are now — with some well-researched and proven smart factory models actually implemented by Harley-Davidson, Audi and other large manufacturers.

Smart factories make it possible for the aerospace and defense industry to manufacture better armored vehicles, missile systems, fighter aircraft and other naval ships — faster, safer and with more precision.

So, let's thank those smart factory pioneers. They have made our jobs significantly easier, since we now have the potential to produce vehicles that are more mobile, lethal and most importantly, survivable.

Learn more at https://www.dxc.technology/aerospace_defense

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