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Accelerating Your Smart Factory Journey

A Guide to Smart Factory Digital Transformation

By Reinier Stomp, Benjamin Arredondo, Emilio Blanco, John Woods and Chad Markle

Digital Twin:
a superior representation of a physical entity or system across its lifecycle using comprehensive data, analytics, simulations and emulations

Digital Thread:
a seamless flow of data that connects business processes across the value chain to deliver top-line growth, improve operational excellence and enable risk mitigation

Take a moment to picture what a fully digital factory should look like. Imagine every part, product and process connected to a **digital twin**, linked by IoT into an end-to-end **digital thread**. Automated systems capture metrics, flag bottlenecks, and optimize solutions in real time, adapting and reacting to changes before they are visible to the human eye.

Smart factories like this are far from fiction. On the contrary, they are becoming essential for continued success in modern manufacturing. Companies across a wide variety of industries – from fashion brand Hugo Boss to consumer goods giant Procter & Gamble to industrial equipment manufacturer Stanley Black & Decker – have started implementing this digital era must-have.

In this eBook we will address common development challenges during factory conversions and lay out a path to successfully transform any production plant into a smart factory.

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Evolving Technology, Consumer Demands and The New Normal

From the Industrial Revolution up to the end of the 19th century, technology grew at a relatively consistent pace.

However, this growth exploded at the turn of the century, most notably at the start of the digital era. Since 1965, humanity's computational ability roughly doubled every two years, while in the last 10 years connectivity, data storage, and sensor costs decreased by more than 4,000%[1]. Meanwhile, advances in analytic tools, batteries, and other technologies converged to dramatically increase manufacturing efficiency and technological capability.

At the same time, consumers have shifted their expectations. People do not only demand high-quality products at an optimal price point, but they also want products to be tailored to their exact preferences and have them shipped to their door in the blink of an eye. Consumers want to modify products to fit their identity and taste from the comfort of their homes – a preference that is often not compatible with traditional mass-production manufacturing methods.

For example, Nike allows consumers to choose from several shoe designs, and then mix and match colors, patterns, textures, and engraving.

These developments are further accelerated by COVID-19. With around 40% of workers remote even after the pandemic[2], companies are turning to digital technology to remain resilient throughout the pandemic.

It's important to find ways to support office workers who need to work remotely and to enable manufacturing lines to keep running by using digital manufacturing capabilities. For instance, one globally operating tier 1 automotive supplier started using augmented reality (AR) to enable its central engineering team to service its plants around the world remotely, instead of travelling to each site as they did before the pandemic[3].

Logistic disruptions caused by developments like the pandemic, along with rapidly changing trade agreements, tariffs and other protectionist governmental policies, have dramatically increased the pressure to produce closer to the consumer. Traditionally, labor costs have been a strong driver to relocate manufacturing overseas, but there is pressure now to move at least part of the production volume back onshore. There's even more pressure for specific industries like pharmaceuticals to produce certain drugs and medical devices in their home countries.

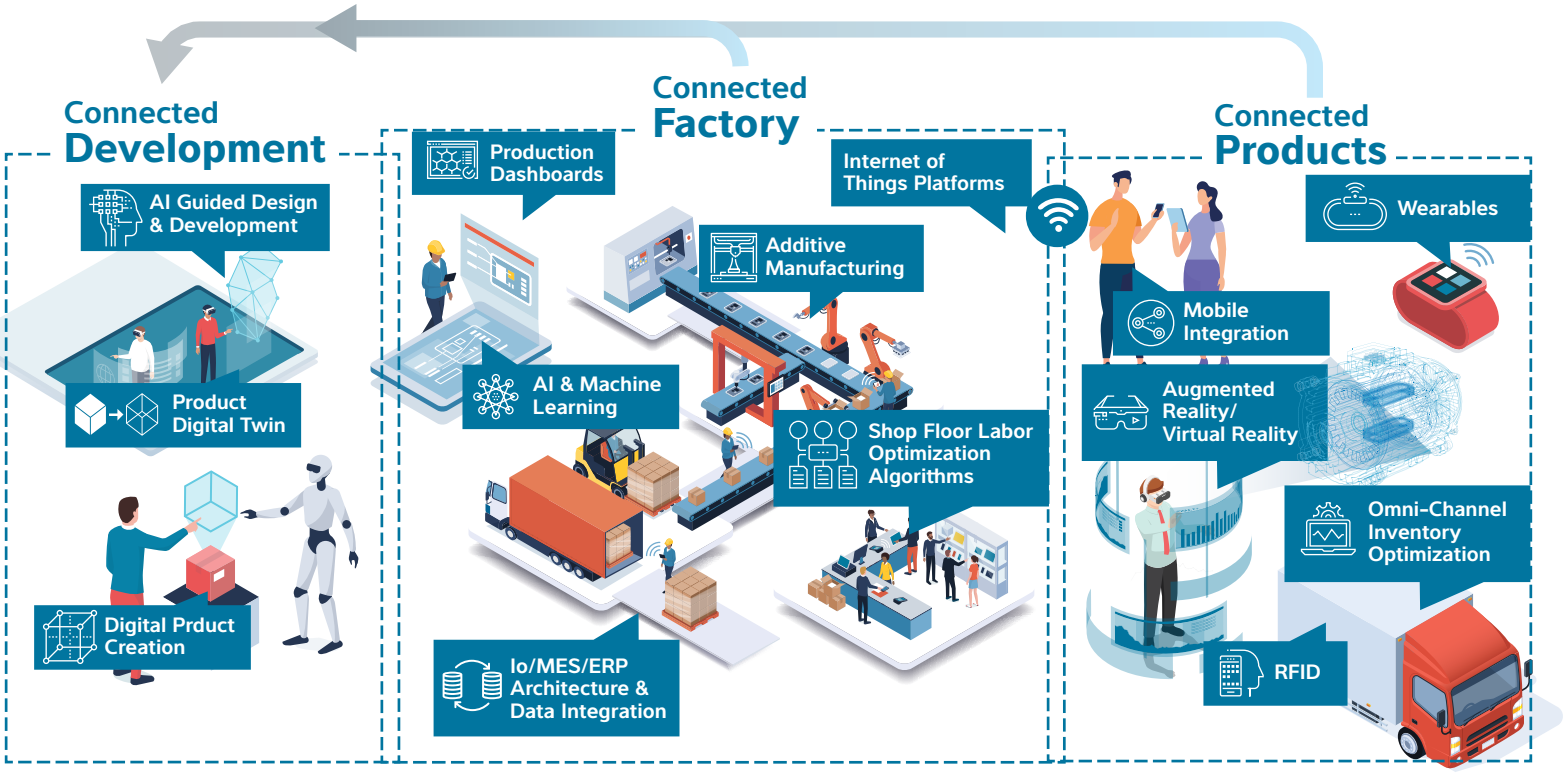
Under these conditions, traditional labor-intensive processes – which might be profitable in countries with lower labor cost – are increasingly less feasible.

Moving forward, the only way to manufacture profitably will be to use highly digitized production methods that enable the manufacturing workforce to reach its full potential.

1 Roser, Max, and Hannah Ritchie. "Technological Progress." Our World in Data, 11 May 2013, ourworldindata.org/technological-progress.
2 https://www.gartner.com/en/newsroom/press-releases/2020-04-14-gartner-hr-survey-reveals-41--of-employees-likely-to-
3 https://www.ptc.com/en/resources/manufacturing/video/vcst-smart-factory-technology

Introducing the Smart Factory

The smart factory is a digitally enabled manufacturing facility in which the physical production process is fully integrated with a supporting digital technology ecosystem. The smart factory is a key component of the digital thread and an increasingly vital solution for modern manufacturing.



As highlighted above, the smart factory uses a combination of digital technologies – including IoT, AI, machine learning, and others – to digitize manufacturing operations by connecting them through a digital backbone that acts as an orchestrator of the production process.

The physical product production flow is supplemented by a seamless flow of information that is both complete and readily available, which is also referred to as the digital thread.

Smart factories enable a more efficient and robust manufacturing process through the following dynamics:

Enabling proactive decision making

A smart factory empowers individual workers and plant managers to make better, proactive decisions based on real-time data. It eliminates islands of information and creates a functioning data backbone with one data model that harmonizes information technology (IT) and operations technology (OT) domains with third-party data. The data backbone provides real-time insights into product materials, assets, and people without the need for manual data manipulation or cleansing.

A good example of proactive decision making is predictive maintenance, which has started to be heavily adopted by leading manufacturing, power and energy companies. They use IoT to predict machine and pipeline failures, and proactively make repairs and part replacements before larger breakdowns occur[4].

Blending digital & physical experiences

A smart factory makes information about equipment and processes available in ways that cross the traditional boundary between the physical and virtual world. It provides live data from IoT-captured processes to make performance dashboards and virtual replicas of the plant available for management to access from anywhere. Additionally, the smart factory enhances plant workers' capabilities by providing augmented reality (AR) solutions that project data and instructions for equipment operations and maintenance based on live data, removing the need to refer to manuals or other devices.

A luxury car manufacturer has taken advantage of AR to train production line personnel during their onboarding. This allows them to achieve a more efficient, interactive and safe training experience while ensuring a new employee is ready when starting on the actual production line.

Enhancing situational awareness

A smart factory leverages sensors and extended reality to increase the data and information at people's fingertips. With easy access to information, they can spot bottlenecks and identify potential issues early on. For instance, a plant manager can have an interactive map of all production lines in her facility. With that, she can drill down from a top-level view to the lowest level of detail to see the current status and efficiency of each line and piece of equipment in the plant.

4 https://www.hrdive.com/news/how-mercedes-benz-uses-augmented-reality-to-train-employees-of-all-types/530425/

Increasing real-time automation

A smart factory reduces repetitive, manual efforts and enables people to focus on the work that adds most value while creating a safe paperless and touchless environment. It automates tasks and makes knowledge readily available to other associates, which minimizes the need for manual interference, improves learning curves and enhances process quality. As the cost of intelligent sensors and devices continuously decreases, there are more opportunities to embed them into the production process. Once embedded, they can detect minor deviations in the environment and process throughput to automatically trigger adjustments in the production flow if needed.

Improve digital integrations that cross over traditional boundaries

A smart factory integrates information from traditionally separated IT and OT sources to create one harmonized data fabric. It goes beyond the traditional walls of the factory to integrate data from marketing, sales, and third parties to optimize production mix and volumes. It combines its own data with reference data from equipment suppliers to enable predictive maintenance and optimize overall equipment effectiveness (OEE).

OEE:

is a "best practices" metric that identifies the percentage of planned production time that is truly productive.
An OEE score of 100% represents perfect production: manufacturing only good parts, as fast as possible, with no downtime

How to Get Started on a Road to Success

A true smart factory journey promises strong value, the journey can be counterproductive if embarked upon incorrectly. Whether you are experienced or a newcomer into the field, making a factory smart can present several challenges.

Navigating the abundance of available technologies. Deciding where to get started or what tools to implement is difficult, particularly since it is not always clear which technology is the best option for your specific needs.

Gaining the support of stakeholders. Even the most effective smart factory journeys can be delayed by stakeholders who are either unaware or skeptical of the benefits of this type of transformation.

Avoiding the temptation to work on pilots from promising technologies without full consideration of the company's strategy and existing technological developments.

Unfortunately, adopting the newest technology without a clear vision often fails to address the most significant opportunities for improvement and, over time, increases the risk of having many scattered technologies that are difficult to integrate after their individual implementation. As a result, efforts to integrate smart technologies can result in reduced efficiency and wasted capital.

A better approach is to focus on value, leveraging technology to deliver this value and designing for scalability. To address this in more detail, we recommend the following steps to start and accelerate a successful smart factory journey:

Map out your smart manufacturing strategy

- Understand **the industry dynamics** that impact value creation and surface the **opportunities** that must be addressed
- Prioritize opportunity areas to establish **a strong Smart Factory Vision** that includes training, maintenance and other manufacturing aspects, and establish milestones for ongoing management
- Ensure **leadership support** for the Smart Factory Vision
- Create a **'north star' business objective** to cut through the variety of possibilities and focus your objectives
- Evaluate digital maturity and set **clear smart factory targets** for the next three years
- Build measures and **scorecards** that reflect the smart factory strategy
- Form a **powerful guiding coalition** and encourage others to act on the vision

Create smart project pilots to prove value

- **Empower a dedicated team** with resources to be successful in the smart factory journey
- Establish digital proofs of concept and **demonstrate business value**
- Choose a pilot that has tangible connection to operational KPIs
- Take a **cross-functional and agile** development approach with end-users, technology and service providers
- Use **early successes** to gain buy-in from the organization and secure funding for a larger rollouts
- Engage with digital leaders **outside your organization**, by collaborating with consultants, start-ups, universities, or industry organizations to accelerate digital innovation

Define the capabilities you need

- Building on the lessons learned in pilots, define the **capabilities needed** to achieve your vision
- **Design and implement a scalable data model** that will act as a backbone for your smart factory vision
- Develop strategies for **attracting new talent** and improving processes as well as for implementing digital technologies
- Search out and recognize the beginning of **changed behavior**
- Design and implement new **training and development** programs aligned with desired changes
- Continue **changing systems, structures and processes** that don't fit the smart factory vision

Become smart manufacturing wizards

- Identify **smart manufacturing insights** that will unlock competitive advantage and marketplace success
- Consider how you can best organize **data analytics teams**; they should be cross-functional and empowered to get results
- Get value out of smart operations by building **direct links to decision-making**
- Create tight linkage of incentives and rewards to actions and behaviors that support desired business results
- **Keep manufacturing floor people involved,** as they have day-to-day insights and will be interacting with new tech
- Use the data to **improve operations and products** to offer and build new production capabilities
- Uncover tough-to-find information, connect extensively to supply chain partners, and build extensive **data ecosystems**

Transform into a smart factory

- Maintain a **sense of urgency** - communicate and demonstrate that you cannot return to "the old way"
- **Institutionalize new approaches** to capture the full potential of the smart factory
- Tightly connect the smart factory plan to the **executive change agenda**
- **Integrate individual solutions** into clusters to eventually create smart production lines
- Foster a **digital mindset and culture,** innovating by rapidly experimenting with digital technologies
- Find ways to **turn data into new strategic assets**
- **Celebrate successes** and wins

Learnings from the Field

1 The factory must lead the initiative

Since smart factory solutions are aimed at providing value within the existing operational processes, a main driver of the initiative should be operations functions. A program that is led by the business, focusing on driving improvements in safety and production, is much more likely to succeed. Typically, the best combination is a model where the business drives the process, with IT and key technology partners as collaborators and enablers.

Factory leadership should focus the initiative to provide meaningful value for the manufacturing process. This also helps convince enterprise level executive leadership to support the scale up and embed smart factory solutions throughout the company. This support is required to move beyond the pilot or proof of value phase.

2 Avoid overdoing the plan

Establish a vision, but remain agile as the real value starts to emerge. Through the execution of the digital initiative, the original plan almost always shifts in the direction of the highest value use cases. There is limited value in spending excessive time and effort to define a very detailed business case and rigid implementation plan. Keep the transformation agile. The main necessities are a strategic vision, active leadership endorsement, and building on proven value.

3 Embrace failure and learning

Adopt an agile mindset and allow for failure of proofs of value, especially when they are early in the process. Implement a mechanism to learn from failures and adapt to these learnings when starting new initiatives.

4 Do not make a single technology the hero

A single piece of technology cannot and will not provide all the desired results on its own. Before implementing any technology, make sure that it can interface with the existing backbone to support other technologies, and confirm that there is a plan in place to properly fit the technology into the physical production process.

5 Avoid implementing many technologies that do not integrate

Just because there are many technologies available and other companies are implementing them, does not necessarily mean they are best for your company. Not all technologies work well together and not all technologies are right for your specific factory needs. Before making any decisions, establish a set of hypotheses around the architecture and prove those out during a proof of value. Be sure to involve qualified subject matter experts (SMEs) to ensure the technology implementations will help achieve the defined objectives.

6 Bring in local process subject matter experts

A good smart factory team leverages people in the plant to incorporate their knowledge of the process directly into the solution design. It is a mistake to design a solution from the outside without fundamental knowledge of the specific production process at the site where a new technology will be embedded.

7 Avoid operating in silos

Do not keep everything to yourself. Communicate pilot programs throughout different departments and locations. This will avoid duplicating work and spending unnecessary resources. Additionally, others might be able to provide valuable knowledge acquired through past experiences and projects. This open communication could even help to connect different locations with less issues along the way.

8 Get beyond the pilot phase

The purpose of a good pilot is to prove the value case and test the set of architecture hypotheses. While it is certainly tempting to do numerous pilots to evaluate different types of technology and try out multiple vendors, this should be limited. An over-extended pilot stage delays full implementation of digital technology and deviates the team's focus away from delivering value in the primary production process.

9 Integrate data governance

As different technologies are implemented, creating connections between traditionally segregated IT and OT domains, it's likely that data is defined differently in these systems or they may not be interoperable. This significantly reduces the potential value of smart factory solutions. To address this, data governance and standards should be key considerations at the core of the smart factory initiative.

10 Don't assume one use case configuration fits all

The goal should be to roll-out proven technologies to multiple plants. However, production processes, equipment and connectivity might differ from location to location. Companies should not blindly plan to roll-out solutions to all locations, but rather assess which solutions fit which locations and prioritize a plan that delivers value across the organization within reasonable timelines.

11 Create smart factory experiences

When trying to manage change at scale, it's much more compelling to showcase how new technologies can make a real difference within a plant than to show generic technology demonstrations that are not related to the company's specific production processes. After the first technologies have proven their value in the pilot plant(s), it is a good opportunity to create experiences that can be shown to managers from other plants and regions. This can be in the form of a setup at the pilot plant where colleagues from other plants can visit, or a roadshow that travels to different locations, or even virtual experiences allowing people to immerse themselves remotely.

12 Communicate progress and celebrate success

It might not be feasible to create a detailed long-term plan in advance. This can cause some anxiety in the organization about when changes might come. To help overcome this and even change anxiety into anticipation, celebrate early successes and clearly communicate decisions to roll-out successful proofs of value to other plants.

Case Studies

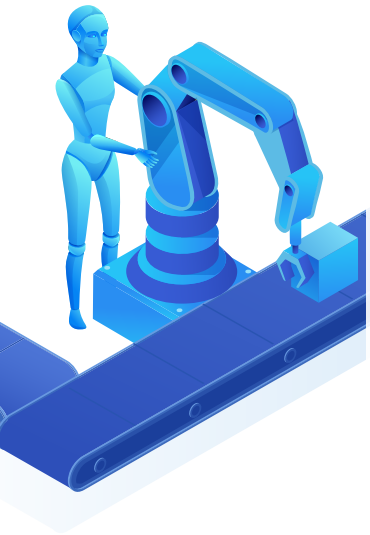
This might sound like it is easier said than done, and that is certainly true. However, there are several examples of industry leaders that have overcome the challenges of the smart factory journey and successfully created an environment that fuses technology with human capability to obtain better results. Here are two examples:

Case Study - Stanley Black & Decker[5,6]

Stanley Black & Decker Inc., an S&P 500 company headquartered in New Britain, Connecticut, is a global provider of hand tools, services and equipment for oil & gas and infrastructure applications, as well as mechanical access solutions.

They had a challenge to improve the production lines in their Reynosa, Mexico plant. They wanted to achieve the following:

- Store as little inventory as possible and still serve the requirements of their customers
- Merge technology with people, with as seamless an integration as possible
- Improve the overall efficiency of their production lines



With 40 multiproduct manufacturing lines and thousands of employees, Stanley Black & Decker embarked on an effort to efficiently introduce real-time visibility into all production lines. They opted to implement an IoT and networking solution consisting of:

1. A highly networked factory floor
2. Multiple hand-held devices, and Wi-Fi RFID tagged assets
3. Real-time alerts and dashboards

As a result, they have gained real-time visibility and traceability, along with faster decision making. They've also increased throughput by 10% and reduced inventory by 10%.

Case Study - Hugo Boss[7,8]

Hugo Boss competes in an ever-changing, unpredictable market. They supply over 900 thousand suits, two million shirts, and 550 thousand pieces of women's apparel from a single location. So in 2016, Hugo Boss decided to start its journey to create a digital environment in its largest factory.

They started out by creating a "simple" three step plan:

1. Create a digital twin of the factory
2. Include robotics and automation
3. Add an artificial intelligence focus

Of course Hugo Boss had some struggles, such as identifying the data they really needed to collect and analyze from their production lines, overcoming resistance to change from traditional to digital methodologies, and even staying at the forefront of technological advances to have the best processes possible.

Joachim Hensch, Managing Director of the Hugo Boss factory in Izmir, Turkey, makes an important point. He says that they are not replacing people; just teaching them new ways and enabling them to do things better with the aid of technology. In fact, during a TEDx conference, he even talks about how the analytics and predictive algorithms they implemented allow them to know which operator will make a specific mistake - with 93% accuracy. This is a game changer which allows management to take counter measures and plan better for increased productivity.

The Bottom Line

Whether you are building a brand-new smart factory or transforming a traditional plant, your company will need a well thought out strategy to successfully integrate new technologies and stay agile in this rapidly changing marketplace. The leading practices and common pitfalls outlined in this playbook will help you build the right team and bring experienced professionals to the table as you start your smart factory journey.

Although this article is primarily concerned with smart factory development, smart factories are only one part of smart connected operations (SCO). Ideally, the end vision is to connect multiple smart factories to suppliers, customers, and logistics providers to create a smart connected production network. Within this, all actors in the supply chain share data and there is live end-to-end insight into the value chain. This will allow companies to have full visibility of supply and demand and be able to react to disruptions and changes without delay.

For more information on smart connected production network, we invite you to take a look at our article on **Factories of the Future**.

5 "Manufactory 4.0: Our Advanced Manufacturing Center of Excellence." Stanley Black and Decker, 10 Oct. 2019, www.stanleyblackanddecker.com/manufactory.

6 "Stanley Black & Decker Opens State-of-the-Art Advanced Manufacturing Center of Excellence in Hartford, CT." Stanley Black and Decker, 10 Oct. 2019, www.stanleyblackanddecker.com/article/stanley-black-decker-opens-state-art-advanced-manufacturing-center-excellence-hartford-ct.

7 Zha, Weixin. "How Hugo Boss Is Turning Its Biggest Plant into a Smart Factory." Fashionunited, Fashionunited, 13 July 2020, fashionunited.uk/news/business/how-hugo-boss-is-turning-its-biggest-plant-into-a-smart-factory/2019102245860.

8 How to Turn a Regular Factory into a Smart Factory | Joachim Hensch | TEDxDEU https://www.youtube.com/watch?v=p-SLDuMW_6k

KALYPSO
A ROCKWELL AUTOMATION COMPANY

For more information, please contact:

Reinier Stomp
Senior Manager
reinier.stomp@kalypso.com

Benjamin Arredondo
Technical Consultant
benjamin.arredondo@kalypso.com

John Woods
Global Director
john.woods@kalypso.com

Chad Markle
Global Director
chad.markle@kalypso.com

Emilio Blanco
Technical Consultant
emilio.blanco@kalypso.com

Analilia Morales
Lead Designer
analilia.morales@kalypso.com

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