

# Industry 4.0:

Using Simulation and the  
Predictive Digital Twin to  
Support Successful Digital  
Transformation





# Foreword by the Author

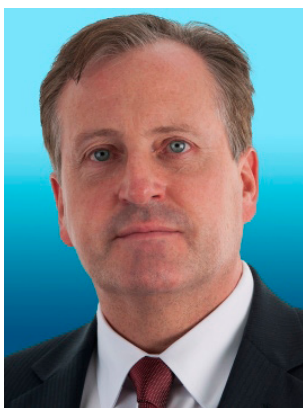
You can't flip through a trade magazine, attend a conference or browse social media without reading about Industry 4.0, the Internet of Things (IoT) and connected factories.

Most business leaders now recognise that Industry 4.0 is the future of manufacturing and that they need to get on board. In the Annual Manufacturing Report 2017, 23% of organisations said they are embarking on Industry 4.0 initiatives and another 62% intend to do so. Today's main challenge is how to mobilise the 62% into positive action.

However, just because people are determined to take digital steps forward does not mean they have the necessary confidence to make the leap. According to PwC, Industry 4.0 is about "complete value chain transformation". In the Annual Manufacturing Report 2017, 75% of people said they lacked sufficient understanding of the issues and implications of Industry 4.0 for them to fully embark on their journey towards a new digital future.

A better understanding of costs and consequences is needed if the remaining 62% are to commit. They need to identify how superficial technology benefit statements translate into value for their particular business in its organisational context. This will provide the increased understanding and confidence required to activate effective stakeholder engagement strategies, which are crucial to securing the widespread buy-in needed for any major business transformation.

This paper seeks to provide a reassuringly pragmatic pathway through much of the confusing tech-hype that surrounds Industry 4.0 and the IoT megatrend. It shows how the use of the digital twin concept can be elevated through simulation technologies to provide predictive guidance in order to mitigate risk, maximise return on investment and provide the momentum needed to facilitate successful, sustainable digital and business transformation.



A handwritten signature in black ink, appearing to read 'AAitken', with a stylized flourish at the end.

Andrew Aitken  
Chief Operating Officer  
Lanner



## Challenges Facing Those Starting the Industry 4.0 Journey

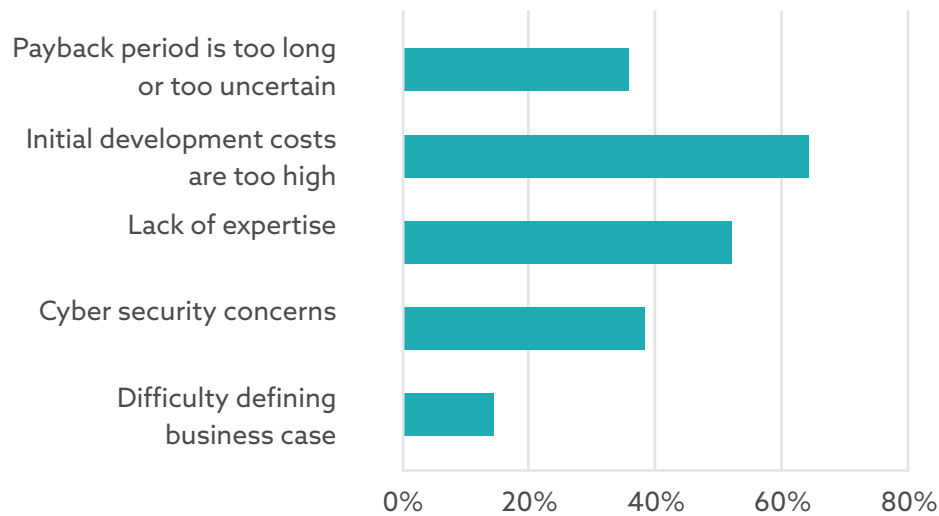
### Mistake 1: Pursuing a technology and data-only approach

Industry 4.0 can involve deploying appropriate automation and data analysis technologies to help reduce machine downtime, realise new efficiencies and deliver increased productivity. Many vendors are encouraging companies to start their Industry 4.0 journey by digitising as much as they possibly can. The Annual Manufacturing Report 2017 found that two-thirds of respondents had invested in automation in the past year, with 71% planning to spend the same or more in 2018.

However, Industry 4.0 should not be solely driven by highly connected automation technologies generating a lake of data for subsequent analysis.

Manufacturers cannot afford to throw away existing capital equipment overnight to implement the latest 4.0 automation – they need to spend wisely. The volume of new technologies available (and the noise that surrounds them) is growing exponentially and can be particularly confusing for small and medium-sized firms. This uncertainty is one of the main reasons why many companies are still reluctant to commit to progressing with Industry 4.0.

## What concerns do you have regarding implementing or continuing to use forms of connectivity?



Source: Annual Manufacturing Report 2017 Published By The Manufacturer

The issue with an automation-spend-first approach is that it's bottom up, starting with operational technology (OT). Often this is accompanied by a vendor mantra of "all new tech is good," which doesn't sit well with many experienced manufacturing decision makers who have been burned before by such blind faith. When we focus only at the bottom of the value chain, we risk investing in something that is tactically led and may not be well aligned with other important issues and questions driving the business. In the worst case scenario, this can result in valuable and scarce resources being invested in technologies that make no material difference to these high-level business outcomes.

Success with Industry 4.0 requires a strategic approach to transformation across all levels and aspects of the value chain. To manage such complexity, the drivers and priorities at the business and operations management levels must be carefully considered before deciding on the most appropriate Industry 4.0 technology approach. Both levels are important and should be synchronously managed.



## Mistake 2: Relying solely on a consultancy-led, externally driven approach

Few companies can undertake any form of digital transformation journey using only their internal skills base. Appointing high quality consultancy support can bring specialist technical expertise, strategic perspective and valuable domain knowledge to the table. Change management experience and independence are also proven benefits that management teams can experience when working with capable consultants.

Many consulting firms targeting the digital transformation market often recommend that some form of Digital Readiness Audit be commissioned.

The consulting team must have a combination of skills to ensure the resulting strategic and technical implementation plans are practicable and driven by your business objectives. It's crucial that you end up with answers to the following questions:



"What are our one year and three year digital business objectives?"



"Does a quantified business case for implementing our Industry 4.0 roadmap exist?"



"Where should we start and what immediate benefits can we expect?"

This is a wide-ranging review of strengths and weaknesses and is intended to indicate the key action areas that need focus to maximise progress towards the creation of a Digital Transformation Roadmap, supported in turn by a Digital Action Plan. When pursuing this route, it's vital to understand the consulting team's skills and experience. After all, digital is an innovative domain where such a track record is in short supply. The level of change involved is likely to incur significant business risks and costs, so it's important to secure the right skills and expertise. Beware any tick-box methodology that maps needs onto a pre-existing, one-size-fits-all solutions portfolio consisting of familiar offerings. The starting point for your Industry 4.0 roadmap should be the clarification of a shared and digital vision – one that engages all key stakeholders, since this will be a long-term, continuous journey.

The technology implementation planning and execution should be grounded in these strategic business objectives.

It's important that new business models and technology implementation plans be tested and validated prior to committing major investments, such as large-scale automation. History has shown that most major transformation programmes fail when they're poorly thought through or based on a leap of faith. Current vendor hype cycles are generating a large amount of confusion around the very real Industry 4.0 and IoT opportunities that do exist, and it's important to remember the basics of managing the balance between strategic and technology priorities.



If you don't achieve the balance between your strategic and technological priorities, the results will be similar to Mistake #1 – a lack of clarity and confidence that leads to inaction. According to the McKinsey Industry 4.0 Global Expert Survey 2016, the implementation barriers for manufacturers with no or limited progress in Industry 4.0 are:

- Difficulty coordinating actions across different organisational units
- Lack of courage to push through radical transformation
- Lack of necessary talent
- Concerns about cyber security when working with third-party providers
- Lack of a clear business case that justifies investments in the underlying IT architecture

## To summarise: success with Industry 4.0 requires an approach that connects strategic and technical, automation and data layers

Effective, informed leadership and planning are both essential ingredients in delivering game-changing levels of performance, agility and customer experience through Industry 4.0.

Predictive simulation modelling can provide a digital twin that connects business questions to the equipment and data. This allows decision makers to test the business performance and cost impacts associated with different technology investment options at the planning stage, reducing risk and negating the need for any blind commitment to Industry 4.0.



# What is Predictive Simulation and how can it secure Industry 4.0 success?

Predictive simulation uses software to create highly visual and accurate digital twin models of dynamic, real-life systems and processes

Predictive simulation models create digital twins to mirror complex, dynamic processes and drive business and operational optimisation. They're a recognised core technology within IoT and Industry 4.0.

The technology originated in the automotive industry, and in the last two decades has been used to de-risk major capital investment and process transformation decisions across every business sector. Within the current Industry 4.0 vendor hype-cycle, many companies are focused on digital twins for assets (product and machines). The concept of creating digital twins at product and machine levels is not new. Many years ago, while working within Unilever's Advanced Manufacturing Division, we developed a fully integrated Computer Integrated Manufacturing (CIM) facility for new bottle design and manufacture.

## GE Digital's Mind + Machines Event: An Analysis of the Wider Industry 4.0 Context

GE currently leads industrial IoT thinking on the digital twin concept (try searching for "digital twin" on YouTube).

At the GE Digital's Minds + Machines Europe event in Berlin this summer, Marc Thomas-Schmidt, Chief Architect for Predix, explained how businesses need to consider the family of connected digital twins required for asset, operations and business intelligence. This broad consideration is necessary to optimise performance and outcomes across the organisation.

It's very important to understand that the fidelity and style of such models will necessarily vary at different levels. Digital twins of dynamically complex processes at the business and operational levels are equally vital parts of the picture, and you must create them to fully exploit the potential of Industry 4.0.

This incorporated a high level of integrated automation and robotic technologies as well as many other IoT/Industry 4.0 features, including the deployment of digital twins at both product and manufacturing system level. The digital twin concept is well proven but not consistently deployed to create full advantage.

Industry 4.0 affects your whole value chain, which means you need to consider aspects above the product, data and machine automation level. Processes involving high levels of connectivity, variability and complexity require predictive simulation modelling if they're to be captured with accuracy. If any two of these factors are present, then other techniques – such as spreadsheets and value stream maps – are inappropriate and dangerously inaccurate for representing the system, given that they use static averages instead of real-life dynamics. This has critical consequences for decision making. As markets become more volatile and companies become more digitally complex and connected, the use of predictive simulation technologies becomes increasingly necessary for those wishing to gain dynamic insights.

## The value of predictive simulation goes beyond insight to foresight – delivering the ability to run “what if?” scenarios

What if we invest in automating this process? What’s the benefit of implementing predictive maintenance on line A or line B?

Predictive simulation technology enables you to understand the impact of each scenario without incurring any up-front risk or cost. Experimenting with pilot studies to test options on a real production line is expensive, time intensive and runs the risk of experiencing failure consequences. When you’re able to test different options in a virtual world before deciding which path to take, you gain cost/benefit clarity across areas like capital investments, resource planning, process design and even service policies. You’re able to make more informed business decisions, engage stakeholders and achieve a higher return on investments.

## 6 Steps to Industry 4.0 Success

Think back to the two common Industry 4.0 mistakes discussed above – pursuing an OT-only approach (automation- and data-driven) or relying solely on an experience-first (often consultancy-led) approach. Predictive simulation bridges the gap between the two. You’re not automating or analysing real-time data just for the sake of it. Instead, you’re homing in on only the data needed to answer key questions and on whether they relate to business problems, operational bottlenecks, inefficiencies or customer servicing opportunities. This puts you in a better position to manage analysts and prioritise their recommended implementations – and move forward with a better understanding of the performance and cost implications of the decisions being taken.

Here are six steps for Industry 4.0 success using a phased and evidence-based approach.



### 1 Create a high level digital twin to secure current-state understanding

Industry 4.0 isn’t just about IT or OT implementation, and it’s not confined to a single layer or business function. It’s about understanding – and then managing with the right agility – the dynamic performance of your operation, enabled through appropriate technology deployment. In parallel with identifying the strategic goals for Industry 4.0, you need a thorough understanding of current state dynamic process behaviour and performance. A predictive digital twin model of such processes at an appropriately high level of detail can secure the requisite level of understanding and form a better starting point for asking and answering the right business questions.

It makes sense to start by using predictive simulation technology to develop a high-level model that gives an accurate and visual representation of the current state.



### How well do you understand the dynamics of your current processes?

"When businesses are starting off with Industry 4.0, we begin by building a high-level digital twin model they can use to test and prioritise changes.

We were working with a high-tech manufacturing company in the US and went through 20 standard analysis questions to help scope the model. Of the 20 questions we asked the management team about current processes, they could only answer six.

This is extremely common in organisations with complex, dynamic and interconnected processes, and there's always a light bulb moment when people realise how little they understand about how their process dynamics really work. Deepening understanding by asking the right questions from the very start is a crucial first step in Industry 4.0, because you need to know your current position before you can set your digital GPS with the coordinates for a realistic destination."

**John Beadsmoore, Projects Director, Lanner**

## 2

### Use this digital twin to boost high-level management engagement

The goal of Industry 4.0 is to create new agility and efficiencies that can deliver superior customer experiences for the lowest expenditure. Such transformation requires total management buy-in. Predictive simulation facilitates this engagement because it helps build a robust business case in a highly visual manner.

Key stakeholders should be involved in setting objectives and scope even before the creation of the digital twin. The visual nature of the current state digital twin is a powerful way of getting key stakeholders fully involved. It forces them to understand the dynamics of their end-to-end operations, question assumptions and interact in a way that deepens knowledge on the way to clearer insight. Doing this sooner, rather than later, helps develop connected systems thinking and will refine assumptions.

Early stakeholder engagement also gives everyone involved the opportunity to understand and appreciate how potential benefits outweigh the pain of the digital change (or not). This provides reassurance that digitisation plans have been thoroughly investigated and delivers the certainty required for implementation success. Having a digital process twin removes much of the

emotion and subjectivity that's often encountered at an early stage of major change. Objectors can be rapidly converted by using the twin to test their concerns, and their more constructive ideas, by running "what-if?" scenarios. It's an engaging win-win. Securing cross-functional buy-in from the start increases progress velocity and the likelihood of implementation success.

## Case Study

**Hayward Tyler is one of the world's leading suppliers of mission-critical electric motors and pumps for the oil, gas, nuclear, industrial and chemical markets. It used predictive simulation to plan an ambitious business growth strategy and communicate its vision internally, as well as to customers and investors.**

Using predictive simulation, Hayward Tyler created an immersive digital twin of its new factory, presenting a highly visible picture of its manufacturing operations (including how they would evolve over the next five to ten years).

The model highlighted exactly what would be required to meet demand and maximise profitability. Multiple influencers of plant capacity and performance were factored in, including peaks and troughs in demand, factory layout, equipment requirements and shift patterns. The model also encompassed key milestones and product mixes, and identified exactly which processes and resources would be needed at each milestone to keep pace with predicted demand.

**This deep insight gave project managers a highly credible plan to present to stakeholders, and the model quickly became an invaluable communication tool**

The model demonstrated the plan's robustness to the company's key banking partner, helping secure funding by providing transparency, demonstrating competency and instilling confidence.

It was also presented to the in-house manufacturing workforce and subcontractors, and has helped Hayward Tyler engage, motivate and secure buy-in from these internal stakeholders. This has contributed to a successful transition to new methods of operation.

Since this achievement, Hayward Tyler's CEO has mandated that simulation be used as the foundation for planning across all the business' facilities. The company were also named Smart Factory of the Year and won the Leadership and Strategy Award in the 2016 Manufacturer MX Awards.



## 3

## Use the digital twin to ask the right business questions and set clear Industry 4.0 goals

Should we automate process A or process B? Should we add one new machine or two to this cell? What we can learn from this data? Shall we just implement a set of sensors on a pilot line and see how it goes?

These questions are typical of those asked by firms beginning their Industry 4.0 journey. When you start here, you run a high risk of investing time and resource only to find you've been fiddling while Rome is burning elsewhere (i.e. a performance bottleneck exists somewhere else). Management's tendency to throw resources at a problem during a crisis often fails for this reason. The real bottleneck could be a technology or process issue, but it could also be skills related, requiring training investment. Such limitations should be understood to maximise the flow of technology investments.

A high-level (lower-granularity) digital twin can rapidly help you understand how processes behave in dynamically different scenarios. The twin can be used to ask questions about new technologies, training assumptions and average operator productivity levels at various parts of the end-to-end process. This means cause-and-effect relationships can be better understood. Taking this approach enables you to focus on top-down business outcomes from the start, rather than focusing on bottom-up solution technologies.

Using the digital twin in this way provides a virtual testing ground for macro-level thinking. This includes the setting of performance targets. Often, new operations are set policies and targets that aren't realistic, even from the outset. This is due to a lack of end-to-end process understanding. A digital twin can assist with this, making it easier to identify and test the right key performance indicators and goals prior to release.

## Case Study

### Telecoms giant BT used a high-level model to help develop a new network proposition

We were brought in by BT, who were introducing a new global network and were holding a "hothouse workshop" aimed at harnessing the improvement ideas of 60 global specialists and managers in nine Kaizen. We created a high-level digital twin of the new network to test thinking around a wide variety of technologies before they finalised their implementation plan.

We had multiple specialists running the twins and interpreting the impact of the new technologies – for example, eliminating a process step, adding a step or changing the

cycle time of a stage activity. Using the twin in this way made it possible to test performance cause-and-effect impacts across the complete global network (and it was possible to test these on the fly). Many teams found their ideas were addressing local issues and simply moving bottlenecks instead of eliminating them. The teams then collaborated to refine their ideas, validating them with the model to set out the right targets and implementation plan.

**"The use of a high-level, predictive model for the new network enabled us to test and refine our thinking in ways that would not have been possible previously. The resulting design was enhanced and de-risked as a result"**

**Business & Technology Manager, BT**

## 4 Test and prioritise Industry 4.0 implementation options

Armed with new high-level insight and foresight, you can place more focus on the process stages and technologies predicted to deliver maximum (positive) business performance impact. The creation of a more detailed digital twin to gain deeper understanding may or may not be deemed appropriate at this stage. This depends on the relative complexity and commercial importance of the process and decisions in question.


Creating a highly visual model (or models) of operations may be very beneficial when considering major technology and other change options. Such models can be created to immersive virtual reality-level detail to secure lower-level operational understanding and buy-in from the wider operations team.

Picture being able to use a 3D digital twin at a factory or production line level. Consider the value in being able to use this to investigate a critical process stage where different Industry 4.0 technology investments are possible, but where you're unsure which will provide most value. The digital twin enables you to switch in each new technology option (e.g. automation, robotics, predictive maintenance, AR, vision systems) to test their relative costs and benefits within your specific operating context. This is high-order predictive analytics facilitating predictive management decision support. It's at a level above the ubiquitously quoted example of predictive maintenance.



Using the twin in this way enables you to test your thinking around the digital improvement steps you wish to take, so you can proceed to implementation with less risk and more confidence. Having the ability to switch performance improvement technology options in and out to gain a better appreciation of their respective cost vs performance merits is ideal for business case development and implementation planning.

This pragmatic approach creates a more structured, systematic and lower-risk approach for identifying the most efficient and effective Industry 4.0 or IoT transformation pathway. It's an approach that can demystify Industry 4.0 in the context of your specific operating context. The highest impact technologies can be identified and implemented first as this approach can help ensure that Industry 4.0 plans are built on strong performance delivery foundations and have maximum positive effect from day one.



### **Start with quick wins, but spend smartly on smart technology**

"With Industry 4.0, people often start with predictive maintenance because they're being told it's a quick win. But the effectiveness will always depend on your operating context. Applying the latest sensor technology to every part of your asset base is unlikely to be the right course of action – particularly when the warning time between potential failure and catastrophic failure (the P-F interval) is inadequate for carrying out preventive repair or a replacement task.

In some low-performance consequence situations, the right strategy may be to run to failure; for high-consequence modes, re-design may be mandatory. Failure consequences must drive condition-based maintenance actions and priorities. The key is to understand these failure mode priorities within the context of the end-to-end performance system – and a digital twin model can help such strategies.

You need to deploy intelligent technology intelligently. Instead of digitising everything and running pilot schemes – which takes valuable time and resource – you can prioritise using your simulation-powered predictive digital twin. And with Industry 4.0, it's crucial that you take this strategic, informed approach if you're going to build an investment case and realise the benefits."

**Jan Slajer, CEO, Dynamic Future**

## 5

## Develop skills, acquire appropriate technologies and implement the technologies

We've discussed how a digital twin, driven by predictive simulation, can provide a navigation system through the different stages of your Industry 4.0 journey. Having established the specific prioritised technology investment plans that work best for your unique operating context and maturity level, essential skills and capabilities must be put in place in readiness for implementation – either through acquisition or development and training.

This always takes time, and good use should be made of industry innovation resources to tap into available advice and support networks. The UK Catapult Centre network is a prime example – it includes the Advanced Manufacturing Research Centre at the University of Sheffield, The Manufacturing Technology Centre in Coventry and the Advanced Forming Research Centre at the University of Strathclyde Glasgow. These centres are playing an increasingly active role in spearheading Industry 4.0 technology research, development and supporting knowledge transfer for such technologies into UK companies. They have physical Industry 4.0 technology demonstrators and supporting technical expertise on hand to help you identify the right training, suppliers and funding routes. This supports a more informed approach to investing in new advanced technologies. It creates the certainty to empower a smarter business future and enables you to future-proof your Industry 4.0 investments.

As you proceed with your individual 4.0 implementation, you can use the predictive digital twin to track the value being delivered against planned goals and key performance indicators. This can help keep implementation on track and ensure investment returns are maximised on an ongoing basis. After all, successful performance results are the lifeblood and a key to the sustainability of any major change programme, and Industry 4.0 is no different. In the end, results will determine the level of long-term stakeholder buy-in and sustainability achieved.

## 6

## Move from continuous improvement to continuous innovation

Given its aim of continuously improving operational agility and customer response, the Industry 4.0 journey has no end. After all, customer appetites for new products and service differentiation will never again be totally satisfied.

As a result, operations teams across all sectors must realise that the traditional continuous improvement foundations, based on historical data and traditional process analysis techniques, may no longer be sufficient to keep up. Instead, businesses need to anticipate tomorrow's innovative performance differentiators and act before someone else does. We are in the age of continuous innovation enabled by digital technologies – and it's time to move fast or die.

The predictive digital twin has the power to provide management with a virtual piloting environment to encourage innovative (sometimes radical) new thinking. It enables those responsible for the evolution of business operations to be more proactive in their stance towards new market and customer demands. At Lanner, we call this business gamification.

Instead of grappling with a myriad of technology implementations and/or drowning in new data sources, feeding an already overflowing data-lake, the suggested approach offers a more systematic and progressive approach towards securing sustainable competitive advantage through Industry 4.0.

## Predictive Simulation will underpin Industry 4.0 Success

Clearly, Industry 4.0, the Internet of Things and connected smart factories – complete with automation, networking, edge analytics, robotics, AI and VR – offer UK manufacturers an opportunity to boost their competitiveness and thrive in a changing global landscape.

Planning and executing an Industry 4.0-focused digital business transformation strategy is a complex change management task, and you shouldn't view it as a technology-first project. The technologies are powerful and important, but they must be managed. Consulting-led approaches can add value and important strategic perspective but must also be tightly controlled to maximise returns in realistically short timescales. A predictive digital twin can provide a visual and quantitative way of validating and connecting the strategic 'thoughtware' layer with lower level OT and IT layers.

Before you dedicate resources to either automation, AI or consultancy, it is important to understand the dynamics of your current state and then test the impact of technology investment options to establish impact-vs-expense priorities. This foundation is essential for developing a robust investment case, as well as for implementation planning, results validation and subsequent transformation ideation.

Predictive simulation has a recognised role to play throughout the Industry 4.0 lifecycle because it provides the clarity needed for successful implementation. It acts as a navigation system for managing rapid technology change and delivering to volatile market expectations. At the same time, it helps minimise risk and maximise profit from newly available Industry 4.0 technologies. And that's why it's fast becoming the new norm for businesses across all sectors.

## Using Predictive Simulation to create a roadmap for Industry 4.0 Success – 6 Steps to Success



Using Simulation and the Predictive  
Digital Twin to Support Successful  
Digital Transformation

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