Practical Pathways to Industry 4.0
The obstacles to digital transformation and how manufacturers can overcome them

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Management Summary

- New research from Siemens Financial Services has highlighted the top two major obstacles to a successful transition to Industry 4.0 as digital skills and access to finance for the scale of investment.
- Across the fields of production, maintenance and analytics, manufacturers interviewed for this study identified the six key challenges to digital transformation:
  - Challenge #1: Developing the digital skills required for a successful transition to Industry 4.0
  - Challenge #2: Access to finance for the scale of investment that manufacturers need to make over-time in digital and automated technology platforms
  - Challenge #3: Creating the culture of collaboration needed to work together for success in a connected Industry 4.0 world, whether in-house, within the supply chain or across industries
  - Challenge #4: Overcoming data and cybersecurity concerns in a world where high volumes of sensitive data move over the internet
  - Challenge #5: Gaining comprehensive access to a broad enough volume and range of proof points – real examples of successful digital transformation in all manufacturing sectors
  - Challenge #6: Specialized strategic management capabilities to create a clear, phased plan to achieve Industry 4.0

- Research respondents also identified the main factors that need to be considered in order to create a successful digital transformation plan, with key questions that fall into the following categories:
  - Integrated strategic finance
  - Developing digital management
  - Measuring efficiencies
  - Recruiting and training talent
  - Assessing obstacles
  - Evaluating opportunities

- Respondents clearly recognize that finance and strategy development are interconnected and should be considered simultaneously as the first step in plan development. This is because a clear view of financing possibilities fundamentally influences strategic thinking and option evaluation about "the art of the possible" when moving to Industry 4.0.
The compelling need for most manufacturers to digitalize and automate their operations is now very widely recognized by the leading manufacturers and specialist management consultants interviewed for this study.

Ultimately, an ideal digitalized and automated Industry 4.0 world is one in which people, machinery and systems are all digitally linked. It is a world where technology automatically adjusts or recalibrates itself for greater efficiency, quality or customization. It creates capabilities for preemptive maintenance to improve uptime. It is an environment where powerful digital data flows seamlessly within and between organizations. And it creates a culture where collaborative groups work together up and down the supply chain to build better, more productive, industrial ecosystems.

Getting to the summit of full Industry 4.0 transformation, however, is likely to be reached in a series of steps, rather than a wholesale and sudden change. Even though the pace of product and market development in digitalized manufacturing has been breathtaking, experienced managers know that they risk dangerous business disruption if they move too far, too fast, without quality controls and return-on-investment measures firmly in place.

The debate has moved, therefore, from discussing the simple need to digitalize and automate to understanding how organizations create a practical path to Industry 4.0. In an attempt to uncover this path, Siemens Financial Services interviewed manufacturers and expert management consultants in eleven countries around the world about the hurdles manufacturers face in the process of moving to an Industry 4.0 model: What are their main challenges to digitalization and automation in practice? What are the interrelationships between those challenges? Are they technical or cultural? How is a successful strategy developed? What skills are needed at each stage of development? And, crucially, how is that transition financed, and what are the implications for return-on-investment?

The following section of this report outlines the top six challenges, as ranked by research respondents. It then moves on to examine interviewees’ opinion on best practices in creating a practical path to overcome those challenges: What information and insight needs to be gathered to create a viable strategy and plan? What are the key areas of objective self-examination for the organization? What business processes, management attitudes, financing strategies and cultural factors need to change?

Interviewees around the world were asked to identify their key challenges to implementing Industry 4.0 – digitalization and automation – whether within their own company, in their industry and/or in their country. In addition, interviewees were also asked to rank those challenges in order of importance.

**Challenge #1 Digital skills**

The highest-ranking issue was digital skills. Respondents clearly defined three key areas of digital skills where shortages are already being experienced. The first area was digital production expertise, which enables operational staff to interpret machine and performance data on their handheld dashboards and take appropriate action. The second-most mentioned skill area was digital maintenance capabilities, where engineers have the know-how to maintain complex digitalized operating systems and equipment. The third digital skill shortage area was operating and strategic analytics, where analysts are able to interpret the reams of “big data” generated by the completely digitalized environment – including production data, supply chain data, market data and financial data – in order to create and interpret valuable insights to improve competitiveness.

Along with the rising tide of skills shortages, respondents also highlighted the need to embrace outsourcing in order to address some of these growing digitalization skills requirements. Commentary was particularly focused on complex data analytics, where respondents anticipated extreme difficulty in attracting, retaining and affording the relevant in-house talent. As a result, interviewees also expect growth in the emerging field of manufacturing analytics.

“In our view, the skills shortage is less about shop floor staff and more about finding senior managers who are digitally literate, experienced and strategic.”

Wood Products, China

“We don’t have the systems infrastructure or the skills for big data analysis. It would be commercial nonsense to develop this in-house... so we outsource.”

Construction Machinery, India
Challenge #2
Access to finance for the scale of investment

The second-greatest challenge to Industry 4.0 adoption, according to respondents was a need for access to finance for the scale of investment over time in digital and automated technology platforms. Even where the economies of retrofit are possible, or the transformation can be divided into a logical series of steps, the pace and size of investment is nevertheless often considerable. A proportion of respondents used the phrase “capital load” to describe this challenge. All interviewees believed that without access to appropriate and sustainable third-party finance, manufacturers are precluded from acquiring the required digitalized technology for effective digital transformation.

Financing requirements were positioned as the second-most important issue on the road to Industry 4.0. While many manufacturers may have a clear view of what technology is needed to achieve Industry 4.0, the question is how to do so in a financially sustainable way that allows them to compete effectively in an Industry 4.0 world.

Challenge #3
Creating a culture of collaboration

After finance and skills, respondents ranked creating a culture of collaboration as the third-greatest challenge. This is seen as a key challenge in the manufacturing sector, which has historically had a clear demarcation of roles and responsibilities. Now, Industry 4.0 is creating an interconnected environment where multiple perspectives – engineering, production, logistics, finance, sales, product development, etc. – can be combined and viewed in parallel to identify potential improvements or business opportunities. Being able to work collaboratively with other functions and with third-party providers is now being seen as a key skill in its own right, with some organizations actively investing in specific training.

The extent of collaborative activity also raises issues of trust. In a traditional competitive supply chain, buyers want to pay as little as possible, while suppliers want to charge as much as possible. The balance between these positions can be disrupted if supplier and buyer transparently share production and performance data. In such a situation, the supplier may fear that this transparency could lead to pressure to decrease prices. Respondents to this study noted that digitalization has resulted in discussions around new business models in which collaborative transparency from the supply side is matched with longer guaranteed contractual commitments from the buyer side.

“If you look at our industry, and at many other industries too, the technology we need is changing and developing all the time. The changes are so fast-paced when it comes to digital industry. So financing tools and techniques need to match and accommodate that pace of change. The time to invest is getting shorter.”

Electronic Components, Germany

“A culture of collaboration must be implemented – it’s not something that can be achieved simply through technology. People – individually, as groups, even in different organizations – have to learn to work together for mutual gain within the industry.”

Plastic Injection, UK

“We haven’t yet built this collaborative approach sufficiently into our culture – we’re well on the journey but have to keep working at it. All our people need to learn to debate and collaborate as a matter of course.”

Machine Building, Spain
Challenge #4
Data and cybersecurity

The Internet of Things (IoT) is a key tool for connecting people, machines and systems within Industry 4.0. Moving large volumes of competitively sensitive data over the internet, however, heightens the need for data and cybersecurity. While respondents unanimously noted that information security is a wider issue for all modern businesses running cloud applications, the subject remains a key concern, whether in terms of operational disruption due to hacking or in terms of the exposure of commercially sensitive information.

Over half of the interviewees were of the opinion that these information security concerns are likely to give rise to a future market in specialized secure data-sharing services. Several respondents made a comparison with existing secure data-sharing industries – such as credit referencing – where participants contribute information into an anonymized environment to gain shared insights without the fear of data loss, exposure or identification.

“We think the most important challenge is concerns about data and cybersecurity. When we send the information to the cloud, how can we effectively control access to this often sensitive information?”

Machine Tools, Turkey

Challenge #5
Comprehensive access to proof points

Although manufacturers interviewed for this study seem clear about the Industry 4.0 technology solutions that they need to acquire, most also note that a lack of comprehensive access to proof points is hampering investment decisions in their sector. Proof points are defined as case studies about manufacturers’ investment in Industry 4.0 technology that clearly illustrate the level and period of return on investment. In some areas of the manufacturing industry, certain suppliers have gathered and published detailed case studies; however, the coverage across the range of manufacturing sectors is not universally visible. It is possible to find some pockets of excellence where case studies and industry initiatives/proofs of concept do exist and are publicly available. These might describe a company’s return on investment or outline financing arrangements that are making it easier and sustainable for manufacturers to invest in digitalized technology over time. Nevertheless, respondents to this study concurred that a much larger body of such proof points is needed to help companies invest with confidence – reliably calculating expected commercial and competitive benefits. To this point, several interviewees called for the technology suppliers and the specialist financier community to build a more comprehensive global library of anonymized proof points – possibly to increase and accelerate Industry 4.0 investment decisions across all manufacturing sectors.

“It is not yet clear enough how the money invested in digitalization will generate return. In my industry, access to such proof points are the main obstacle for successful development of digitalization.”

Maritime Equipment, Russia
Challenge #6
Specialized strategic management & planning capabilities

Finally, among the top challenges in making the transition to Industry 4.0, is the issue of specialized capabilities for strategic management and planning that are needed to establish a vision and strategy. Ultimately, these translate into an action plan that can be put into practice on an operational level. While respondents noted that almost every manufacturer’s main board is aware of the urgent need to digitalize and automate, too few have converted this recognition into a clear, phased, strategic plan. Governments are facing the same challenge with weak planning paralleled at national policy level, according to the EU.14

Such planning includes methods of evaluating the commercial benefits gained from each phase of investment, organized into a process where each phase is measured, and its impact on the following program phases assessed and suitable adjustments made. Pioneering manufacturers who have created an agile, phased Industry 4.0 program have often done so by creating a collaborative group of peer companies, management consultants and specialist financiers who, together, bring a clear view of both the practical and the possible – ambition combined with risk management.

“When it comes to digitalization and Industry 4.0 transformation, there is often a lack of more precise vision at the top of manufacturing companies. What needs to be done and in what order? What will the commercial outcomes be? How does each initiative build on the last? How can we minimize disruption? How can we escape from the merely tactical?”

Carbon Steel Products, Poland

Creating a sustainable plan for Industry 4.0

Manufacturing companies and management consultants interviewed for this study were adamant on one very important point – building a sustainable plan for Industry 4.0 cannot be reduced to a single, simplistic formula. Each company’s circumstances, digital maturity, market dynamics, management capabilities, talent pool and financial capacity are different. Respondents agreed that a coherent approach – a methodology – that scrutinizes a number of aspects of a manufacturer’s business is the key to building a sustainable plan for digitalization and automation. The most effective transformation plans, interviewees noted, are those based on a phased “test, review, learn, improve” process.

The methodology emerging from this study reflects consensus among respondents over six key areas of self-examination: assessing obstacles, evaluating opportunities, measuring efficiencies, recruiting and training talent, developing digital management, and integrating strategic finance. Typical sub-questions cited by respondents have been synthesized in Figure 3.

Three particularly interesting insights also arose from the collective voices of study respondents.

Consider financing options and strategy development simultaneously as the first step

Perhaps most interesting was the new perspective on finance underlined by interviewees. In essence, this involves moving the financing question up the strategy chain to the very first stages of strategy and plan development. In other words, rather than build a technical solution and then determine viable financing solutions, the new approach is to integrate the question of financing into the phases that deal with designing and building a technology solution strategy (see fig 2). Anecdotal feedback reveals that this approach can open the door to “better fit” specifications and solutions that may not otherwise have been considered. Innovatively structured financing (for example, integrating flex payments to align with the predicted rate of return on investment that the Industry 4.0 technology is expected to produce) opens up a greater vista of possibilities and also helps to make the solution financially sustainable.

“The industry is becoming increasingly competitive and equipment is overtaking human resources in its ability to help drive a business forward. In this vein, it makes sense that more organizations are moving their businesses forward by looking at digital technology options in the context of the financing we can raise.”

Aviation Parts, France
Establish concrete measurements for every phase of the plan

One goal must always be to measure return on investment from each stage of an Industry 4.0 phased plan. Respondents talked about the challenge that this represents, but also the absolute necessity of putting tangible, financial measures of success in place. Without this rigorous approach, there is no opportunity to clearly evaluate success or failure from each phase of the plan. In addition, the availability of flexible financing to acquire Industry 4.0 technology is increasingly being predicated on those expected commercial outcomes. Measurable outcomes might include energy savings, productivity gains (lower pricing/increased sales/increased margin), more competitive or faster product development, faster market reaction, etc. Moreover, the measures put in place should be founded on collaborative work completed, for example, among internal departments, between supplier and buyer, or between financier and technology provider. This makes it possible for all parties to both contribute and commit to those measures of success.

“There is a new person taking over the running of our company soon. He is 45 years old – so not a digital native, but relatively young. He is specifically tasked with carving out our digital automated future.”

Engineering, Sweden

“Digitalization simply allows you to measure more – it provides the means of doing so. For each phase of our development, we monitor, having created our own internal measurements. Quality, for instance, is a key business concern these days, and you can closely measure improvements there, along with their commercial impact.”

Plastics, UK

Develop ‘digitally fluent’ leadership

Recruiting and developing a digitally fluent workforce has been earmarked as a key challenge for the transition to Industry 4.0. The issue extends to members of the senior management who have to understand the digitalized environment in order to successfully lead an Industry 4.0 enterprise.

Since the leadership cohort in most organizations is more likely to be senior, and probably middle-aged, they are less likely to be from the “digital native” generation. Respondents emphasized that this creates the need for a concerted program of management development and training for most manufacturers. They also remarked that much rests on the culture for change and agility already present in the management and leadership layers. A previous track record for successful change and adaptation among a company’s leaders, those surveyed explained, is a highly positive sign for personal leadership growth in a digitalized manufacturing environment.
**Assessing the obstacles**

- Is your business development vision built on a solid basis of data and factual analysis?
- What are your partner dependencies in the supply or distribution chain – and could they undermine your success or slow you down?
- Do you have enough access to robust and proven business cases where measurable success has been achieved?
- What additional strain will implementing a digital platform put on your organization?
- Is there a danger that your chosen technology investments could become rapidly obsolete in a fast-moving digital world?
- Will your employees be enthusiastic about the shift to Industry 4.0 or be resistant to it? Have you consulted them on their fears and/or ambitions?
- Have you assessed the increased risk of cybersecurity and data security in an IoT environment?
- Have you assessed the skills requirement and availability to run your digital factory?

**Recruiting and training talent**

- Have you conducted a skills-gap analysis between your current workforce and the requirements of your digital factory? How high is the potential for retraining?
- Have you brought your employees enthusiastically onboard for change? Are they likely to resist?
- Do you already have a “culture of collaboration” among your workforce? Are their rewards and incentives designed to encourage cooperation and collaboration?
- Have you planned your likely need for skills in:
  - Operational data interpretation
  - Digital environment maintenance
  - Strategic optimization analytics
  - Virtual environment manipulation
- Have you analyzed the available skills market and compared it with your emerging Industry 4.0 needs by way of a gap analysis?
- Have you identified which skills to develop in-house for competitive advantage and which to outsource to specialists that you are unlikely to attract in-house?

**Developing digital management**

- Do you have full board consensus on digitalization? Are there any board members who are skeptical or lukewarm?
- Is there full commitment to invest properly in Industry 4.0?
- Have you constructed a new business model and rationale for how you will operate in an Industry 4.0 world?
- Do you have a proven management culture of learning, agility and successful change management?
- Do your main decision-makers have digital skills and experience? If not, have you engaged proven experts?
- Is there planned investment in management development for an Industry 4.0 operating model?
- What are the new performance metrics for your new digital manufacturing operation?
- What management positions are made redundant through digital transformation (if the answer is “none” or “few”, then the transformation plans may not sufficient)?

**Evaluating the opportunities**

- Have you precisely defined what you expect to achieve through Industry 4.0 growth?
- Where are you situated on the road to Industry 4.0 compared with your key competitors? Ahead? Behind? By how much?
- What are the low-investment and the high-investment growth opportunities? What will they deliver? Have they been set in order of priority? Which ones are extendable? How will they protect or create value?
- Have you analyzed which investments can be acquired instead of building?
- How reliable are the financial and competitive benefits of digital transformation, including originating your strategy, creating a culture of collaboration and operationalizing your plans?
- Which of these savings can be best achieved through retrofit and which require full technology replacement?
- How much could you save through:
  - Increased uptime through predictive maintenance?
  - Reduced setup time?
  - Reduced energy usage?
  - Production optimization through IoT analytics?
  - Improved just-in-time production (e.g. through MES extensions)?
  - Error reduction?
  - Overall improved productivity?
- Which of these savings represent the quick wins? And which will either take longer or require higher investment?
- What is their minimum target for achieving measurable success?
- Which savings are extendable? How will they protect or create value?
- Which ones are extendable? How will they protect or create value?
- Is there a danger that your chosen technology investment growth opportunities? What will they deliver? Have they been set in order of priority? Which ones are extendable? How will they protect or create value?
- How much do you expect to increase market share and/or profitability through:
  - Greater agility through digital data-based insights?
  - Connectivity within your organization and sites?
  - Connectivity with the distribution/supply chain?
  - Improved order-to-delivery timing?
  - More rapid product development?
  - Better customer service through order tracking?
  - More customized products per customer?

**Measuring the efficiencies**

- How much could you save through:
  - Overall improved productivity?
  - Improved just-in-time production?
  - Production optimization through IoT analytics?
  - Reduced energy usage?
  - Error reduction?
  - Reduced setup time?
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  - More customized products per customer?

**Integrating strategic finance**

- Do you have financing partners who have the willingness and the skills to work with you to create financing options tailored to your specific circumstances?
- Is your CFO a “virtuoso” in linking Industry 4.0 initiatives to financial outcomes using all available financing techniques?
- Have you analyzed which investments can be acquired or create value?
- Have you precisely defined what you expect to achieve through Industry 4.0 growth?
- Where are you situated on the road to Industry 4.0 compared with your key competitors? Ahead? Behind? By how much?
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Financing 4.0 to enable a sustainable plan for Industry 4.0

As a strategic first move, manufacturing organizations should seek to understand the potential access points to financing for digital transformation, according to the manufacturers and management consultants interviewed for this report. The repositioning of financing, as an early consideration, potentially serves to open the range of technology investment options available as part of strategy development in the quest for Industry 4.0.

The main point in considering financing possibilities in tandem with strategy development is that options may emerge that the manufacturer might not otherwise have considered or might have considered unaffordable. The matter of affordability also brings mitigating operational risks into the picture. For example, while new equipment or a new technology platform system is being set up, tested and rolled out into service, most companies will need to continue running their old systems to ensure continued production. Yet this can create a financial strain as the organization has to pay for both old and new systems for the transition period. Specialist financing techniques can structure payments to address this potential cash-flow burden. Early consideration of financing options therefore often opens the doors to a wider range of possible strategic moves, enabling the manufacturer to realize ambitious goals without compromise and without undue operational risk.

“Managing and financing the acquisition of new-generation digital technology is always the most important challenge – the starting point.”

Pharmaceutical Equipment, China

“Close on the heels of the big six challenges comes the issue of compatibility – that is, migrating information from legacy systems to the digitalized environment. This is an issue in terms of both money and time. ... It’s really time-consuming and firms need to be prepared.”

Travel Products, USA

Pay to access/use equipment & technology finance
Ensures the acquisition of a system or piece of technology. Hardware, service, maintenance and other soft costs can be embraced in a single agreement. Periods can be flexed to match payments to the financial benefits gained. Special arrangements can also be put in place that help to accelerate future technology acquisitions.

Pay for outcomes
These arrangements base payments on the expected business benefits, or “outcomes”, that automation or digitalization technology makes possible. Actual financial savings – such as reduced electricity consumption – are used to subsidize or even totally fund monthly payments, making the technology cost-neutral for the manufacturer.

Technology upgrade and update
Manufacturers want to access technology innovations as they appear (particularly in light of shortening digital innovation cycles). Finance can also offer options to upgrade technology during the financing period, whether to replace certain elements with a newer models, or retrofit enhancements into the main technology platform.

Transition finance
Manufacturers do not want to start paying for their Industry 4.0 technology platform until it is installed, tested and operational. Finance 4.0 recognizes the challenges of transition and offers financing arrangements that defer payment for a new system until it is reliably up and running, eliminating any period of cost duplication for the manufacturer.

Working capital solutions
Finance can be optimized in more areas than technology acquisition. Improved competitiveness can lead to sudden growth – which exerts pressures on supplies, inventory and overall cash flow. Financing services – usually based on some form of invoice finance – are available to help manage the broader financial challenges brought on by success in digitalization.

Software finance
By definition, most Industry 4.0 technology solutions involve both hardware and software. Because specialist financiers understand how the software is implemented, and the benefits in practice that it is likely to deliver, they can understand the associated risk and embrace the software element into a total financing package.

“If we hadn’t used specialist finance, we would have had to use our own money. This means we would have had to divert our own working capital to finance our assets, which in the case of long-term assets is not desirable.”

Industrial Valves, India
Key references

1 Digital Transformation, or Industry 4.0, is defined by McKinsey in the following way: “Industry 4.0 is the next phase in the digitization and automation of the manufacturing sector, driven by four disruptions: the astonishing rise in data volumes, computational power, and connectivity, especially new low-power wide-area networks; the emergence of analytics and business-intelligence capabilities; new forms of human-machine interaction such as touch interfaces and augmented-reality systems; and improvements in transferring digital instructions to the physical world, such as advanced robotics and 3-D printing.”

2 See, for instance: The Manufacturer, “67% of UK manufacturers recognise Industry 4.0 opportunity” (May 15, 2017).

3 See, for instance: McKinsey, “Industry 4.0 demystified – LEAN’s next level” (March 30, 2017); Advanced Factories, “Where innovation shapes industry 4.0” (Sept. 1, 2017); Information Age, “Industry 4.0: top 10 critical trends” (Dec. 28, 2016); Forbes, “What Everyone Must Know about Industry 4.0” (June 20, 2016); PwC, “Building the Digital Enterprise” (April 13, 2016).

4 BCG, “Time to Accelerate in the Race Toward Industry 4.0” (May 19, 2016).


6 Sixty-one manufacturers and specialist management consultants were interviewed by telephone during October and November 2017. Manufacturing interviews were with CFOs and Financial Directors. Respondents came from the United States, the UK, France, Germany, Spain, Sweden, Poland, Turkey, Russia, India and China.

7 See, for instance: EEF, “An up-skill battle” (March 28, 2016).

8 See, for instance: Germany Trade & Invest, “The Machinery & Equipment Industry in Germany” (2017/18); PwC, “Companies worldwide are investing heavily in digitization” (April 13, 2016).

9 For a parallel view of the position of finance as a key enabler of productivity, see, for instance: KPMG, “Rethinking Manufacturing” (2017).

10 See, for instance: Deloitte University Press, “Industry 4.0 and building a culture of responsibility at the workplace” (Oct. 31, 2017).

11 For a concise infographic, see: PwC, “Cybersecurity and privacy risks of Industry 4.0” (Feb. 1, 2017).

12 See, for instance: Fraunhofer Institute Industry 4.0 programme; Business Value Exchange, “DXC’s Industry 4.0 Platform Eases Path to Smart Connected Manufacturing” (July 20, 2017).


14 European Commission, “Key lessons from national Industry 4.0 policy initiatives in Europe” (May 2017).

15 According to Siemens Financial Services research, published in Investing in Success (2016), 60% of manufacturing respondents observed that technology replacement/upgrade cycles are shortening.

16 This whole subject is discussed in a Siemens Financial Services research paper, Opportunities and Outcomes (Feb. 2017).