



Creating Lasting Value in the Age of AI+IoT – Futureproofing your Business

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The pace of technological change is accelerating. In factories this acceleration is coupled with a large installed base of legacy equipment and systems, supported by a workforce that is shrinking in size as workers retire and new entrants of younger workers are dwindling. In addition, the industrial sector is facing a skills gap as traditional workers cannot meet the needs of the new digital transformation sweeping factories.

The ecosystem technologists may not be dealing with their own large installed base of legacy equipment, but they are dealing with an ever-evolving IoT technology stack. At the same time, they are facing stiff competition for limited AI and IoT savvy talent. Like their manufacturing counterparts, ecosystem technologists struggle to keep their skills current to serve an ever-changing digital world.

Fifty-four percent of our study technologists expressed these concerns and worry about their ability to keep up. Moreover, they worry about making choices today that will limit their options in the future. In other words, they are seeking guidance about how to **Futureproof** their business, their operations and even their own careers.

The Future is Already in Flight

Companies are not sitting still in this era of digital transformation. In fact, many worry that they are going to get left behind by their competition if they don't invest in smart technologies and solutions. Over 80% of our technologists reported that their company currently had plans to invest in advanced technologies in the next two to three years. For some of these companies it is a matter of additional investments in technologies already in use and for others these are new investments. Table 1 highlights the top 10 planned investments.

OVER 400 VOICES IN A TWO-PHASE STUDY

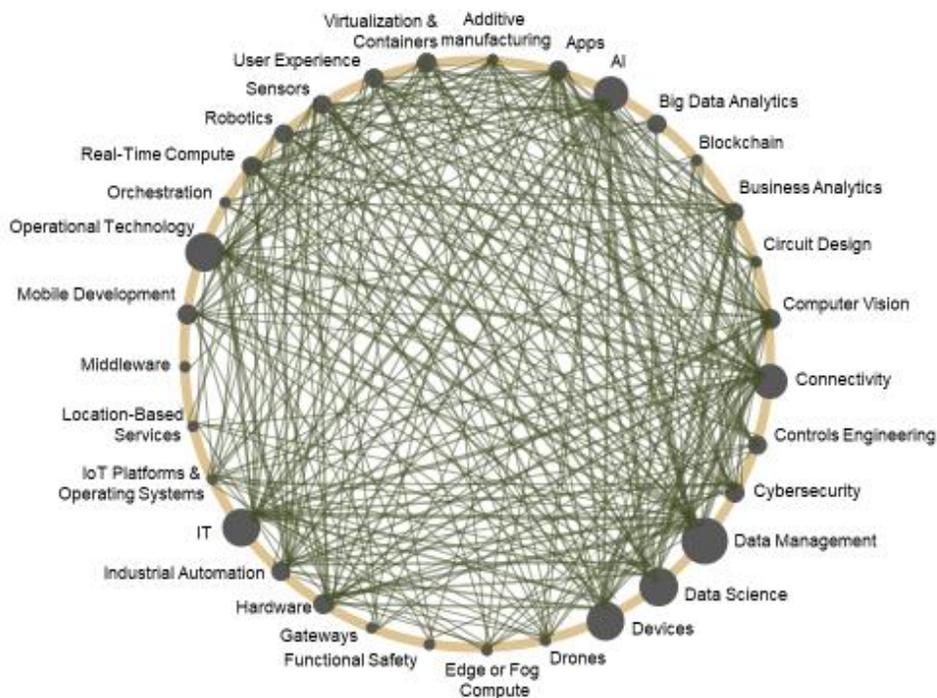
Since 2018, Drs. Faith McCreary and Irene Petrick have been exploring the industrial landscape to better understand the changes that digital transformation will drive in factories and in the ecosystem companies that support them. The research includes 404 manufacturing and ecosystem company participants, including 193 technologists directly involved in creating and implementing smart technologies. This research relied on mobile ethnography and interviews, resulting in nearly 19,000 pages of participant transcripts. A broad range of discrete and process industry sectors are included. The two-phase study began with a look inside the factory, determining that Industry 4.0 would require that workers co-evolve with manufacturing operations.

Creating Lasting Value in the Age of AI+IoT – Futureproofing Your Business is one of the reports of phase 2, which focused on the technologists in factories and their ecosystem vendors and suppliers. Additional reports in this series include: **Twelve Strategies to Jumpstart and Sustain Digital Transformation, Standing up Successful Smart Technology Projects, Leading Digital Transformation and Being AI Ready.**

Table 1: Top 10 Planned Investments (% of respondents)

51%	Artificial Intelligence
44%	Predictive or big data analytics
35%	Smart machinery or equipment
31%	Robotics
29%	Smart upgrades to existing equipment
25%	Additive manufacturing (3D printing)
24%	Smart building
23%	Smart asset tracking or monitoring
19%	Virtual or augmented reality
18%	Blockchain

In the smart technology solution space, technologies are often interdependent. In fact, almost no smart technologies are deployed as a single solution. Figure 1 captures what technologists told us they needed to blend in order to stand up smart solutions. The size of the dot on the circumference of the circle indicates the percentage of participants who expressed that this is an important technology in their arsenal. The lines between various dots reflect the interdependencies, with thicker lines indicating that more participants identified this interdependency between technologies. We note that the participants were not provided with a list of technologies and asked to “check all that apply”. Instead these were generated through a series of open-ended questions.



**Figure 1:
Technology
Interdependencies
in Smart Projects**

But understanding technology interdependencies and planning investments is not enough to ensure success. Technologists stressed the need to think beyond the horizon of today and to balance current pain points with future anticipated needs. Those participants most pleased with their activities are taking a system of systems

view and doing end to end lifecycle planning. For them, change is a continuous process and reflects the notion of digital transformation as a journey, not a destination.

A vision of what digital transformation might help the company achieve should be in place before any project implementations. Technologists and senior leaders also pointed to the importance of basing investments on a solid foundation, with 43% indicating that a healthy vision should build on what has made the company successful today, and cautioned that taking “giant leaps” beyond this foundation was rarely successful. This vision should drive a roadmap for change that reflects a 3-5 year timeframe on average. A good roadmap is a living document that evolves as the company’s digital activities mature. Prioritizing and resourcing the vision and roadmap appropriately are a necessity. Looking at the total cost of ownership (TCO) reduces unanticipated expenses along the journey.

“I think having a clear picture of the road you want to travel to get to where you are going and having a roadmap that can get you to your final destination is the most important thing.”

-- Internal Consultant Working in an OEM

Visions aren't static things; planning for obsolescence must be proactive. Change avoidance is not an option. Instead, companies must decide what to ignore, what to make future ready today in anticipation of tomorrow's options, and what will be dealt with down the road at a more convenient time. Framing a vision and executing incrementally is a recipe for success.

Capacity to Change

Capacity is about the ability to execute total work **and** change management activities. Unrealistic expectations for AI and IoT increase the stress technologists face when trying to roll out and sustain smart solutions. This tension plays out as a decelerator to change, with 23% of technologists indicating that their companies commit to change but don't achieve it; 16% reporting that their companies are willing to change but are not equipped, and 11% complaining that their companies were too much talk with too little action.

It turns out that successful Lean practices in the past decades are often a harbinger of challenges today in digital transformation. Often employees are inclined to distrust efforts at transformation as merely a way to reduce headcount or increase workload responsibilities. Moreover, the financial focus on Lean emphasizes short-term ROI that is making it difficult to get needed capital expenditures and change activities approved for the longer-term ROIs associated with digital transformation. These conditions often result in change resistant organizations.

The Risk of Obsolescence

But AI and IoT technologies constantly evolve. In the consumer world, many smart things have been designed to be replaced every year or so, even if only to acquire the latest features. This mindset carries over to industrial ecosystem providers today. However, that approach doesn't work very well in the industrial space where manufacturers must recertify their processes as they are updated or retrain their workers as operational needs change. Factors that increase the risk of obsolescence include organizational brittleness of culture, processes or people; ecosystem instability resulting from trade wars or regulation; unreasonably high bars for ROI; or a lack of industry acceptance of a technology solution resulting in its discontinuance by the provider. Table 2 highlights specific technology-based concerns that have the potential to derail the effectiveness of smart technology investments (as reported by at least 15% of respondents).

Table 2: Top Technology Challenges Most Likely to Derail Future Plans in the Next 2-3 Years

- 36% TECHNICAL SKILL GAPS that prevent us from benefitting from our investment
- 27% DATA SENSITIVITY from increasing concerns over data and IP relative to privacy, data ownership and management
- 23% LACK OF INTEROPERABILITY between protocols, components, products and systems
- 22% SECURITY THREATS both in terms of current and emerging vulnerabilities in the factory
- 18% HANDLING DATA GROWTH in amount and velocity as well as sense-making
- 18% SCALABILITY ROADBLOCKS to accommodating growth without business or performance loss

The most proactive technologists designed for obsolescence from the start using tried and true software engineering techniques like designing for portability, utilizing core platform architectures across systems, or isolating critical functionality likely to be impacted by future technology changes. Among the most mentioned solution features that prevent obsolescence are comprehensive suites of APIs that provide full access to backend functionality likely to be impacted by changes down the road; and plug and play components, and capabilities that are protocol agnostic or at a minimum support a broad range of industrial protocols.

The Skills Gap

The skills gap reflects the changing nature of digital manufacturing operations. To successfully implement and maintain digital solutions, a company must have a workforce that possesses “digital dexterity” – they must understand the manufacturing processes and the digital tools that support those processes. Table 3 highlights the top five critical skills for today and for the future. A careful reader will note the shift to digital skills needed for the future, where the top five skills are all digitally related. Manufacturing knowledge was relegated to #6, a dramatic shift.

Table 3: Top Five Critical Skills for Today and the Future

Skills Today What adds the most value today	Skills Future What to grow or strengthen for the future
1. Basics of modern programming or software engineering	1. Deep understanding of modern programming or software engineering techniques
2. Manufacturing skills	2. Digital dexterity, or the ability to leverage exiting and emerging technologies for practical business outcomes
3. Great communication skills	3. Data science
4. Innovation skills (e.g. brainstorming, design thinking)	4. Connectivity
5. Traditional IT skills	5. Cybersecurity
	6. <i>Manufacturing skills</i>

Companies seeking to bridge the skills gap should

- Create programs that support life-long learning among the existing workforce.
- Offer instruction in digital tools and skills that combine both lecture and hands-on opportunities to practice.

- Emphasize problem assessment and solving before solution implementation to prompt discussion and learning.
- Balance hiring external experts and internal staffing when standing up new smart technology projects to grow the company's digital dexterity.

Data Sensitivity

Concerns arise around data and IP relative to privacy, data ownership and data management. This pertains to both internal data sharing and to data sharing with 3rd party solution providers. To successfully implement an AI algorithm, for example, requires that there is data to train it and test it. Yet many companies are loath to share their data, even with the people they are paying to do these projects. There is also a strong belief that current data governance policies – if they, in fact, exist – are inadequate to represent the realities of digital operations. As more systems are connected through digital tools, siloed and internally focused policies are a hindrance. Companies seeking to avoid the data sensitivity problem should

- Formalize data sharing policies for within organizational data transfer and between company data transfer.
- Establish data governance policies that reflect both the value of data sharing and the potential risk exposure. A one-size-fits-all policy will not suffice.
- Consider data sharing needs prior to standing up a smart project and allow sufficient time to negotiate these needs and embed them into vendor contracts.

Lack of Interoperability

The lack of interoperability between protocols, components, products and systems is not a new problem. Today, however, companies are becoming frustrated with this interoperability as it limits their ability to innovate at speed. They are also frustrated that they cannot upgrade system components easily due to propriety vendor lock-in. Ideally, companies want to be able to swap out one vendor module for another vendor's solution without this lock-in. Companies seeking to avoid interoperability challenges should

- Aggressively support standards by participating in forums and standards bodies aimed at promoting interoperability (e.g., Open Process Automation Forum).
- Demand that vendors work together in developing smart solutions to stress modularity, interoperability, and paths to upgrades over time that are vendor agnostic.
- Consider Open Source options when standing up smart technology projects.

Security Threats

The combination of physical and digital systems in smart factories makes real-time interoperability possible – but it comes with the risk of an expanded attack surface. With numerous machines and devices connected to single or multiple networks, vulnerabilities in any one of these pieces of equipment could open up the entire system to attack. Companies will need to anticipate both enterprise system vulnerabilities and machine level operational vulnerabilities. Companies seeking to avoid security threats should

- Combine OT and IT professionals in smart project teams to assess possible vulnerabilities. Identify people, process, machine and network threats. This OT/IT team should develop shared strategies, standards and tactics for securing the intelligent factory.

- Understand the upgrades vendors introduce into equipment and/or operations and anticipate possible changes to existing vulnerabilities (and strategies to combat them).
- Develop “corner case” analyses where no one alternative or feature may be a critical vulnerability but where the interdependencies between alternatives and/or features introduce or increase vulnerabilities. Plan for these non-obvious cases.

Handling Data Growth

As AI and IoT usage expands, companies will be faced with more data, being generated at a faster pace, and in multiple formats. AI algorithms must be able to combine data that is often of different types or timeframes and they need to be easier to comprehend – i.e., how does the algorithm arrive at a recommendation? Companies seeking to address data velocity and sense-making should:

- Understand the data that yields business value insights and balance computing at the asset level, bandwidth and the need for real-time (low latency) control and feedback.
- Anticipate sampling rates that reflect changes to machine or operational status. Collecting everything may not make sense.
- Develop a robust system architecture before implementation that balances compute needs and the location of those needs (e.g., edge versus cloud), storage requirements today and into the future, and communication infrastructure.

Scalability Roadblocks

Building the future while it is in motion requires special capabilities and capacities. Our participants – in and out of the factory – often verbalized feelings of risk and uncertainty around transforming, transitioning and innovating on their path to their envisioned

“Technology moves at a very rapid pace, but we also have a business to run so the epic challenge is balancing every-day production with the race to maintain our position in the world of technology. We can’t halt production to learn things so we have to evolve at a balanced pace.”

--Quality Inspector at an Aerospace Contract Manufacturer

future. Ecosystem partners often offer to help companies re-invent the factory while it is up and running. However, for many manufacturers the last the thing they want to do is live production while changing their technologies or operations. To reduce the risks associated with change, manufacturers often experiment with proof of concepts (POCs) or pilots that let them try out capability stretching on smaller projects. However, then they are faced with the challenge of trying to scale these smaller projects – and they often find out that what works on a small scale does not work on a larger scale. Companies seeking to reduce scalability roadblocks should

- Make capacity discussions an explicit part of the go/no-go decision before beginning smart projects.
- Carefully consider project schedules to balance both smart technology ambitions and the rigors of on-going production requirements.
- Build in change management practices as part of the expectations for smart projects.

A Matter of Pacing – Manufacturers and their Ecosystem

Nowhere are the differences between manufacturers and the ecosystem more defined than when it comes to futureproofing. Ecosystem players are looking to accelerate the pace at which they are producing updated

versions of their wondrous technologies and getting them to market more quickly. Over 70% of manufacturing leaders, however, raised concerns about their ability to keep up. Despite these differences, both groups are trying to find ways to make their businesses less likely to become obsolete. Yet this mismatched pace is creating update fatigue among operations technologists and frustration in their ecosystem partners.

The way in which companies self-identify their adoption practices is also telling. Forty-two percent of manufacturing technologists describe their companies as *slow to adopt*, while 52% of ecosystem technologists identify their companies as *early adopters*. Within manufacturing companies, one-third of participants indicated that they were slow to adopt, in general, punctuated with bursts of investment and implementation.

Another key difference between manufacturers and their ecosystem companies lies in their willingness to share data. Manufacturing participants are less likely to want to share data, with 46% of participants indicating they would not be willing to share data outside of their company. Only 20% of ecosystem technologists, on the other hand, believed that data sharing across organizations would be a problem.

Culture & Mindset

Digital transformation changes not only the technologies people use, it also changes how these people work together. For both those in the ecosystem and in the factory, corporate culture and employee mindset were considered key to long-term sustainability of their smart initiatives and successful execution on their smart ambitions. Over 75% of participants called out its importance. Some went so far as to suggest that cultural shifts should be made to traditional manufacturing companies before they even attempted digital transformation. Table 4 identifies key characteristics of future proof organizations and individuals.

Table 4: Culture and Mindset Futureproofing Traits (reported by at least 20% of respondents)

	Organizational Traits What organizational traits matter most	Individual Traits What individual traits matter most
Accelerators What to cultivate	<ol style="list-style-type: none"> 1. Discipline and accountability 2. Agility, flexibility, adaptability 3. Forward looking innovation 4. Customer focus 5. Risk taking 6. Learning culture 7. Trust and empowerment of employees 8. Data-driven 9. Proactive 10. Collaborative 	<ol style="list-style-type: none"> 1. Life-longer learner 2. Networker and collaborator 3. Risk taker willing to channel inner maverick 4. Persistent and patient 5. Creative and innovative 6. Systems thinker 7. Agile and flexible 8. Responsible and hardworking 9. Passionate 10. Improvement mindset
Deaccelerators What to minimize	<ol style="list-style-type: none"> 1. Not agile or flexible 2. No real discipline or accountability here 3. Risk intolerant 4. Hierarchical and authoritative 5. Culture of blame 6. Not data-driven 7. Reinvent the wheel not re-use 8. Not innovative 9. Not customer-focused 10. Not open and transparent 	<ol style="list-style-type: none"> 1. Complacency 2. Not collaborative 3. Lack of confidence 4. Fearful of failure 5. Not disciplined 6. Not a systems thinker <p>(Remaining traits did not meet the threshold of at least 20% of participants providing)</p>

Recommendations for Futureproofing

There are three primary groups that may take the insights provided in this study and drive action: (1) manufacturing leaders, (2) technologists, and (3) ecosystem providers. Ultimately, the companies that can embrace these should be able to accelerate their digital transformation. Table 5 highlights futureproofing actions for each audience.

“So the thing about digital transformation and shifting business culture is it takes a long time. That it is not for the faint of heart. So this tends to be a journey. It is not a destination.

*-- General Manager of Global Alliances,
Independent Software Vendor*

Table 5: Actions for Futureproofing

Manufacturing Leaders Futureproofing your company	Technologists Futureproofing your career	Ecosystem Providers Futureproofing your solutions
<p>Develop a holistic strategy</p> <ul style="list-style-type: none"> Focus on infrastructure needs as you envision smart solutions, including a solid cybersecurity foundation Identify and track technical and non-technical challenges, metrics and lessons learned Stand up governance policies that balance ‘quick to deploy’ solutions and ‘able to scale’ practices <p>Build your internal workforce capabilities</p> <ul style="list-style-type: none"> Balance external experts and internal staff for smart projects Create training programs that blend instruction and hands-on learning Emphasize company-wide support for learning <p>Manage your supply chain vendors to maximize value</p> <ul style="list-style-type: none"> Identify key suppliers and build <i>relationships</i> that go beyond individual transactions Develop governance policies and standards to share data 	<p>Identify what you need for tomorrow</p> <ul style="list-style-type: none"> Balance external expertise and internal know-how Grow your internal capabilities with hands-on activities Seek hands-on training at your workplace <p>Think outside the boundaries of your company</p> <ul style="list-style-type: none"> Don't wait for your workplace or your customers to highlight their needs Develop professional connections to keep up to date with trends Develop deeper knowledge about infrastructure aspects of smart technologies <p>While you are the master of your own domain, a fully formed solution will require other skills</p> <ul style="list-style-type: none"> Develop linkages within your organization and outside your company to critical support skills When working with vendors or customers, seek opportunities to participate in strategy and requirements definition 	<p>Remember that you are <i>part of the solution and must work with others</i></p> <ul style="list-style-type: none"> Understand your customer's pain points and future ambitions Develop cross-vendor relationships needed to build end-to-end solutions Focus on modularity, interoperability and standards <p>Faster is not always better</p> <ul style="list-style-type: none"> Manage updates and new introductions to correspond to manufacturer needs – don't outpace the market Preview upcoming features so that manufacturers can better integrate these into planning <p>Anticipate deployment and trouble-shooting support</p> <ul style="list-style-type: none"> Augment technical solutions with easy-to-use development kits Consider service support for deployment as a cost of doing business Think ahead to help your manufacturers anticipate new uses for your solution; suggest how best to scale

Leaders and technologists struggle to identify best practices to futureproof their organization – how to keep their companies and themselves at the forefront of digital transformation. What our work suggests is that a one-size-fits-all approach doesn't take into account unique company challenges. To expand the insights presented here, we refer you to the full ***Creating Lasting Value in the Age of AI + IoT – Futureproofing your Business*** report.

[For more information and to obtain a copy of the extended report:](#)

