SDA Bocconi
SCHOOL OF MANAGEMENT

Industry 4.0: The Digital Plant and Digital Operations

Key Insights and Summary

Center for
Digital Strategies
Tuck at Dartmouth

Industry 4.0: The Digital Plant and Digital Operations

Digital Strategies Roundtable
An executive roundtable series of the
SDA Bocconi School of Management at the Università Bocconi and
the Center for Digital Strategies at the Tuck School of Business at Dartmouth

Much has been made of the digitalization of various aspects of the enterprise, but the manufacturing sector, and especially factories, plants, and the production processes inside them, have received comparatively little attention. "Industry 4.0" refers to manufacturing in the fourth industrial revolution: the part of digital transformation that focuses on production, operations, warehousing and other physical processes. This roundtable focuses on how Industry 4.0 will use advances in technology and intelligence derived from new data to hybridize the physical world with the digital, deliver next-generation productivity, and innovate across the entire value chain.

CIOs and their colleagues in advanced manufacturing from the American Bureau of Shipping, Chevron, Eaton Corporation, Sidel, Tenaris, Tetra Pak and host Owens Corning, along with faculty from the SDA Bocconi School of Management and Executive Fellows of the Roundtable, met to discuss the impact of industrial digital transformation on business models, the relationship between Operations Technology ("OT") and Information Technology ("IT"), and the future of the manufacturing workforce.

Key Insights Discussed in this Article:

1. **Industry 4.0 is very much in the discovery and definition phase.** Early initiatives focus on supply-chain operational optimization, and on new demand-chain revenue streams from data-based services — much of which will require new levels of integration and performance from enterprise-wide infrastructure..... **pages 2-6, 17-18**

2. **The key question about Industry 4.0 is when and where to invest.** Digital techs can be applied anywhere, but the return may fail to justify the effort. In parallel, enterprises need to look to start-ups to fill gaps traditional vendors cannot serve..... **pages 6-10, 17**

3. **Digital transformation in manufacturing is fundamentally about integrated technology ecosystems,** and is inherently cross-functional and enterprise-wide. Functional and technology silos have to be replaced by common processes, platforms, and standard..... **pages 4-6, 10-12, 17**

4. **Success in Industry 4.0 depends on new philosophies towards organization and technology.** IT and OT need to collaborate closely, under one governance entity, with clear ownership and accountability defined for products and platforms.... **pages 6-7, 13-16**

5. **Cybersecurity is now critical to OT too — and is finally getting the enterprise-wide consideration it merits.** OT needs to rely on IT's expertise in cyber and infosec, rather than duplicating it..... **pages 13, 15-16**

6. **Turnkey solutions are shrinking industry value chains.** As innovative manufacturers consolidate product, platforms, and services into turnkey solutions, technology vendors are looking hard from the outside at how to disrupt traditional industries. Delay in pursuing 4.0 initiatives may have long-term existential consequences..... **pages 4-6, 17-18**

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Searching for a Common Thread

"Industry 4.0 is one those terms, like digital transformation, that people have different perceptions of the meaning," began John Gallant, Senior Content Strategist at Ledgewood Media, and the discussion's moderator. "What does it mean for the world you're dealing with today, for your company and for your industry?" he asked the Roundtable participants.

"Industry 4.0 includes a huge body of technologies that companies are investing in heavily," answered Enzo Baglieri, Professor of Practice, Procurement and Supply Management at the SDA Bocconi School of Management. "But those technologies are probably the marginal part of the real transformation."

> Companies are pursuing one of two main strategies: The supply-chain dominant, and the demand-chain dominant. In the supply chain approach, companies adopt new technologies to use data to improve performance in logistics, in inventory management, in manufacturing: The priority is efficiency. They invest a lot without applying the benefits directly to their customers. They improve service levels, but they're focused on in-house performance, rather than on interaction with the market.
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> The demand-chain approach prioritizes how to connect customers to operations in order to improve service. So, there's a polarization of technologies. Supply-chain dominant focuses on hardware investing: robots, sensors, anything that can physically acquire the data. Demand-chain dominant focuses on how to connect customers with my processes, and then how to get the data they can produce for me, transfer to them the data I produce, and transform all of this into a new business.

"They're totally different approaches," Baglieri finished. "Supply-chain is led by operations technology people; demand-chain is led by marketing people, or service people. And IT is in the middle, without necessarily having the competencies to manage either of the two perspectives."

"The challenge of Industry 4.0 and its second cousin, digital, is, 'Where do you apply it?'" declared Steve Zerby, CIO of Owens Corning.

> Digital at every level is a bit of a shiny object right now, particularly because of the consumerization that has touched everybody that we work with, and everybody that we work for. There is a need to automate, but an automation strategy based around taking people out of our plants would be interesting without being particularly impactful. The real problem is eliminating waste in the process, not taking people out of it.

"For us, Industry 4.0 is the use of technology and data to massively improve productivity, quality, and even capabilities," stated Mark Meyer, Head of Global IM for Tetra Pak.

> But we have only a finite amount of resource to apply — so where do we focus in order to get the best return on our investment? There are lots of things we could do

> because we can, but how do we determine the right things to do to get the most impact?
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> We have two very different types of internal production that we can look at. We have industrial machine manufacturing and assemble as well as packaging material production. We also have a huge customer base consisting of process manufacturers. Can we go to market with expert services to help our customers implement Industry 4.0 in their unique situations? And then what would we gain from doing that? There are many aspects of what this can mean for business-to-business manufacturers.

"The pundits' definition of Industry 4.0 is all-encompassing," observed Bill Blausey, CIO of Eaton Corporation, "But for the most part we have said Industry 4.0 is like the layer under the ERP — it's the plant floor activities."

> And our approach varies by industry: We have businesses that are using technology purely for productivity gains, like getting consistency around OEE. We have other businesses that focus on how to improve customer service, and yet others where our competitors are doubling down on software and service businesses, with the intent of landing in manufacturing plants and driving revenue through services well beyond their products.

"So the definition of "Industry 4.0" varies greatly based on a business' market, customers, and how they think about operations," Blausey concluded.

"All the technology that everyone is trying to sell to everybody has definitely muddied the waters," agreed Blausey's Eaton colleague Todd Earls, VP of IT.

> So we've looked for the common thread across all our businesses, and that common thread is the connected digital ecosystem. We make sure that whatever we are putting in place can be connected using common digital technologies, so that whatever the starting use case is, it can expand from there with common components: We need to collect data, so it will have an IoT aspect. We need to analyze data, often with AI or machine learning. There are common digital technologies to apply to OEE, additive manufacturing, smart assembly, automation… It's those common components that create an ecosystem that connects to other assets.

Riding the Hype Cycle

"There is a bit of frustration around the commercialization of all this stuff," Zerby lamented. "40 percent of Industry 4.0 really is brand new, very useful, innovative. But 60 percent of it is products and services that existed three years ago, five years ago, and they're just being re-labeled for commercial purposes."

"So you're saying they're gluten-free now?" Gallant asked.

“Exactly!” Zerby laughed. “You have to sort through what’s real, what’s not, and constantly defend against the people who read in-flight magazines.”

“The marketing scheme has been somewhat beneficial,” demurred Jim Beilstein, VP of Advanced Manufacturing at Owens Corning. “Boards of companies are now asking what’s being done about Industry 4.0. And that drives a set of executive behaviors that leads to accelerated questioning, more value chain investigation, more technology investment. Add in some technology accelerators that allow leap frogs we couldn’t do five years ago, and all of a sudden you have momentum building towards solutions.”

“Sometimes it does work to your advantage,” Zerby acknowledged. “It’s like information security: Nobody ever accuses you of being overly dramatic about the need for security. The ability to walk into any room in your company and thoughtfully declare that we’re going to start, or stop, doing something because it brings a security risk is kind of the same phenomenon.”

“That’s true from a corporate standpoint, but then you get to the budget piece,” noted Carla Williams, Manager in IT & Digital Capability at Chevron. “In the business units we have great vision. But when it comes to budgets, digital is still sometimes viewed as IT, and it’s the first thing to get cut.”

> Either you want to make strides, and have to put your money where your mouth is and make the investments. Or you’ve got to say, “We can’t afford this at this time,” and stick with the status quo, but that doesn’t align with corporate objectives. I’m the IT advisor for the business, partnered with a digital champion on the business side, and we often find ourselves playing middleman, pushing for these objectives on a limited budget, or being the ones to call a spade a spade, which doesn’t necessarily get appreciated all the time. That’s where sometimes there’s a disconnect.

“It’s important to avoid that kind of misunderstanding, about whether or not digital is a priority,” affirmed Luisa D’Amato, Director of Manufacturing Executive Systems & Industry 4.0 project leader at Tetra Pak.

> We’ve categorized the technology shift as an enabler of our new business model, so we just don’t have to discuss the prioritization anymore. “Digital” is the enabler that will support and sustain our business as we move from being a provider of equipment and packaging material to being a provider of services. So we’ve stopped discussing the “digital journey,” and we talk instead about what’s required to deliver integrated services and solutions to our customers.

Shop Floor to Top Floor

“We do have those discussions on supply chain and demand chain,” agreed Alejandro Lammertyn, Chief Digital and Strategy Officer at Tenaris, referring back to Baglieri’s opening comments.

> We look at integration with our customers not just on how we can work together better, but also on how the information that comes with our products, our pipes, would even help to automate their processes. And what we found out was that we had a lot of information that was not being used.
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> There were no links between the running of our steel shop to rolling the pipes to finishing: not even information about the interaction between variables was being taken advantage of, much less in real-time. This is the challenge: How to build infrastructure for growth. We can improve one machine, or a group of machines, but nobody was looking at the whole picture and how to get maximum value out of it. Now we call it 'the connected factory,' and how OT and IT deal with the variables in real-time is critical.

"It depends where you decide to invest the development," proposed Jason Pant, VP of Global Information Services for Owens Corning. "We've done plant work directly in our ERP from the manufacturing side, and then supply chain, and we have a lot of systems underneath. We've got small pockets where we've done this thoroughly, but we're never going to replace all the PLCs in a plant. And yet we have to have the layers to connect them all the way from the shop floor up to the top floor, to make sure they're all talking to each other."

"Exactly, and in the process industry, interconnected processes and sensors and equipment have been in place for 40 years," Beilstein continued. "The epiphany of Industry 4.0 is more of a discrete manufacturing epiphany than a process industry epiphany."

> We've mapped our way towards how we want to build use case size and value proposition from beginning to end. First, we have to collect the data, then present the data in a way that operations can act on it. Then we automate the interactions and the variables. And then we want to get to unit operation optimization, then entire line optimization, and ultimately supply chain optimization.
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> The theory has been there for 20 years, but the tools that are available now make it a much simpler pathway than it's ever been before. They are more democratic, they are more accessible. But you do have to be careful to have the right level of process intelligence built in, because the math will give you whatever the algorithms say, and sometimes a result looks exciting, but is actually physically impossible.

"The reality is, like most things digital, most of these things are not brand-new," Blausey mused.

> The idea that everything was manual for the last 35 years and is now being digitized is a little bit ridiculous. We've been collecting data for a long time, and we've automated many processes. One can argue that technology now lets us bring more data together, in a more connected environment, but the individual pockets aren't that much different. It's like someone created "Industry 4.0" as a term to make us think we're doing something different, but I'm not entirely convinced.

“It’s the integration and the scope and scale, at a whole new level,” suggested Hans Brechbühl, Associate Professor of Practice at SDA Bocconi.

“There’s a paradox about scale, though,” Zerby pointed out. “When you have different outcomes for different businesses and regions, there’s nothing that feels like scale. So you start to create solutions higher up. But as you go higher up, where you find commonality and can get scale, you don’t necessarily get the specific impact that you want.”

“And that paradox shows up in the divide among companies who are digitizing and engaging their connected factories,” observed Dion Hinchcliffe, Principal Analyst at Constellation Research and Executive Fellow of the Roundtable.

> One group is focused on tactical solutions, on automation and optimization at the plant level. Preventive maintenance is a big area, because a lot of very expensive pieces of equipment are out there. But there’s a smaller cohort of companies that are thinking about those higher-level solutions. They’re thinking much more strategically about the opportunities. They’re doing all the tactical things, too, and they’re looking at how to implement at a regional level, or a global level, so that factories can learn from each other’s data and process optimizations, to make sure that every factory and every region is creating the most value for the organization and its shareholders.
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> They can measure things in ways that couldn’t be done before. The data is now the most valuable thing: It’s the new oil, as the saying goes. We’re in the very early days of learning how to productize insights and use the knowledge more comprehensively, but we can already see that data companies are the highest-growth companies in the world, with higher earnings per share and much higher profitability. So manufacturers want to become data companies, but they need much more comprehensive digitization first.

Be Smart About Smart Data

“Optimizing our own production is a given; we have always been doing that,” Meyer agreed.

> Now we have more tools to do it faster. The strategic part is the data. Our 200 billion packages per year can become information carriers. We are in the food industry, so we have to do a lot around traceability: “Where do the ingredients come from? Where did the manufacturing material come from? How has it been handled? Where is it?” If we have a unique code on each package, then any consumer can scan it, and know all these things. That data becomes a huge valuable asset that we can sell directly, in and of itself.
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> The other side is that we can help our customers achieve efficiency in their operations, because we have all our experience — plus all their data. If we deliver that value-add, we secure the stickiness of keeping them as a customer. It’s a completely different strategic value than the data itself. And because we are in there helping you operate, of course we have an opportunity to sell why you should buy packaging material from

> us. Or, you buy an outcome from us, and we get to pick the materials you use. We can start thinking about whether we are the owner of data, or the controller of an environment.

Kashif Mahmood, Deputy Chief Digital Officer of the American Bureau of Shipping, built on Meyer's comments:

> Engine manufacturers are now saying, "We don't want to sell you an engine, we want to sell you engine uptime. But in order for me to confidently sell you uptime, I have to have access — complete access — to your data." Because I have to have enough insights to distinguish myself from the next guy who walks in to sell you an engine.
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> So for the buyer, the investment moves from cap ex to op ex. And the seller has to have a digital twin, in order to make good predictions. 30 years ago, you had to run a digital twin as an engineering simulation. But it was always in a vacuum. Today I can run a digital twin simulation using operational intelligence coming from the field in nearly real-time. It changes the value proposition.

Sidel CIO Emmanuel Cron pulled together several themes in the discussion:

> We have customers who are minimalists, and they wait for things to break to change them. So we use the technology to get data for R&D to modify our equipment, and to change service levels for our customers who are focused on output. For them, we need to apply the full knowledge that we have, while being careful that data doesn't kill data. We have to be careful about how it's extracted and apply the 80-20 rule.
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> And at some point, the supply side and the demand side have to connect. The manufacturing world dictates a drive towards efficiency and productivity, and that needs to shift a bit towards customer experience and service.

"Are there a common set of business outcomes that you want out?" Gallant asked. "Maybe new services, or different revenue streams, coming out of what you're all doing in Industry 4.0?"

"Many have been mentioned," Earls answered. "Process efficiency, better utilization of capital equipment, quality of products. There's a competitive advantage aspect as well: not just lower cost and better pricing, but better service to our customers."

"And then there's the fact that we do have an aging workforce," Earls continued. "At one plant, 80 percent of the workforce is expected to retire in the next three years, and they have a lot of tribal knowledge in their heads that needs to be on some kind of digitally-connected workstation, with commonality to other plants."

"The challenge is how to create a framework to build upon," Blausey summarized. "If you decide X is important in aerospace, theoretically you can take that best practice and deploy it in electrical, or hydraulics. The trick is to do it in a way that creates leverage. Each organization is

different, and how to home in on the sweet spot is not exactly always clear. How do you find the most impactful plays, and create leverage out of them?"

Getting Everyone in the Game

"Where have there been wins along this path towards Industry 4.0?" Gallant asked.

"We are doing lots in supply chain, from zero-touch logistics planning all the way through tendering for the right carrier at the right time at the right warehouse," Pant offered.

> It's all being done by the system, based on data parameters that we've provided. That's saved a lot of manual work. We're using data differently in supply chain, to track our raw materials, helping predict when we might have a shortage that could shut down a plant. In packaging we're using new equipment to take out the manual labor and improve operator safety — that's a big win.
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> In other plants we're coming at product issues more scientifically: Testing to understand the key sensors and the data to identify how to improve process yield. That's the biggest opportunity in our composites business — not automation, not taking labor out.

"The nature of the US railcar system is that you don't know when it's going to arrive," Pant's colleague Zerby continued.

> The ability to create a model that predicts when your car is going to be delayed, and then integrate it into the supply chain, substitutes for hundreds of hours of work. More importantly, it demonstrates that you can reliably put this 'data thing' in the hands of experienced people.
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> The biggest success story is that people are starting to ask, "How can I use data algorithms to do what I'm doing, only better?" That may sound trite, but people are proud, and these are 30-year employees, and the notion that some thing can do better than they can is a big emotional hurdle to get over. And we're getting over it.

"It's not only a success story in terms of adoption, but it also helps to find our next use case," added Annie Baymiller, Owens Corning's VP of Global Information Services. "The people closest to the problems can help us figure out where to apply our best analytics resources, our best data scientists. We can strategize all day long with our commercial teams about what we think the problems are, but it's the confidence that this level of sophistication actually advances problem-solving that brings more problems to the surface."

"And the key to building the capability, to delivering the transformation," Zerby emphasized, "Is that you don't have to go solve the biggest problem in the company. It can be just the biggest problem that a person has, or that one business has. Because if you reserve your resources to only go after the biggest issues in your whole company, then nobody else is in the game. We want everybody in the game."

“And if we can make the initial investment on the problem at hand,” Baymiller finished, “Then we can scale it for lower cost, lower effort, lower resource to another business, and we don’t have to make the double investment. We’ve been finding opportunities to scale across businesses that don’t really have a lot in common, but they turn out to have similar supply issues — which we wouldn’t have thought when we started.”

“The sustainability of a solution depends on the fact that you can repeat the experience,” D’Amato agreed.

> And repeat it with a different customer, in a different vertical industry. Our customers use lines from lots of different vendors: Why should they pick our solution rather than someone else’s? We have to accept the bargain, and integrate lines from other providers, too.
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> So the solution has to be modular and scalable, and as a building block, it has to be able to fit into an overall architecture even when you can’t be the provider of all the buildings blocks. Especially when it turns out that many of the biggest technology providers are just claiming to have solutions, while in reality, many of the providers who are really ready to support this journey are the small companies, the niche companies.

“We’ve had this debate with suppliers,” Beilstein acknowledged. “Do we want a supplier to monitor our equipment and tell us when we need predictive maintenance? Right now, the answer is No: We’ve tuned this equipment, it contains a lot of intellectual property, and we’re going to manage it. We’ll create our own algorithms.”

“We are very selective as to who we give access to data from our machines over the wide area network,” he continued. “We may change our perspective over time, but in critical areas of our process, this is how we will behave. In non-critical areas, suppliers run the whole operation. We don’t care, so long as they meet our quality specs. But these choices become very critical from an IP perspective.”

“The day you recognize you gain greater value from letting it go is the day you need to let it go,” Meyer suggested. “But it’s hard to figure that part out, especially in industrial companies, where intellectual property has been key to what’s created these companies. It’s natural to want to keep everything secret, but in the end, it’s got to be an ecosystem that everyone can play in. And ultimately I make more money because everybody else does all the work.”

“A key point here is that there needs to be an Industry 4.0 ‘grid,’ if you will,” Hinchcliffe declared.

> It could be something like blockchain, with a manufacturer’s data on every product they’ve ever made, when they made it, certify the serial numbers, and identify all the inputs from all the suppliers to that manufacturer. The grid would be used by any manufacturer.

> But those who have the data make the rules. If a company wants to become a service provider in this new world, it needs to think beyond its own products and services, and take a more inclusive and encompassing view. Or else it's going to get trumped by the tech companies, who are absolutely looking to build out this grid.

Places We Never Thought Were Possible

"Where does everyone need the most help in order to advance your goals in Industry 4.0?" Gallant prompted.

"The deployment of infrastructure," asserted Luis German, CIO of Tenaris. "We used to think we could have everything in our own data centers, and we would be able to connect it all by ourselves. But with the level of investment needed to create the infrastructure to run the huge amounts of data that we are now talking about, we feel more confident in having someone else come into a partnership with us. The knowledge in that domain is less critical now, and the critical part for us lies in how we model and track what is done with the data."

"I don't know that it's technology and infrastructure so much as organizational dynamics," Blausey offered.

> Answering "How" is not all that difficult, but we haven't solved sorting through "What" at the company level. Product managers traditionally look for tweaks on physical products, but we don't own enough landscape — we can't even partner with someone to own enough landscape — so that we can win on solutions and services, instead of products. That kind of broad thinking comes from an almost software product management perspective, and it's a different skill than we've traditionally needed.

"How much do you worry about someone bringing digital technology to your industry and just knocking your foundation out from under you?" asked Stephen Plume, Managing Director of The Entrepreneurs' Funds and Executive Fellow of the Roundtable. "And/or protecting yourself from that outcome by disrupting yourselves based on opportunities you see in the new technology?"

"We've looked at that question," Blausey answered, "But in our industry, on the platforms where we play and in the places where we could be disruptive, we haven't yet found that secret sauce."

"We looked at a lot of potential disruptive ideas in our next 10-year plan," Meyer concurred, "And we kept coming back to, 'What's the potential revenue stream from these supposedly-disruptive ideas?' When we added them all up, the actual market opportunity didn't add up to half of what we'd lost last year in something else. They looked big, but when you got to the actual economics, none of them were enough to drive the kind of growth we were looking for. So our plan went back to looking at incremental innovation in the core, to maintain and grow that core."

Beilstein provided a counterpoint:

> We do have segments where we think we can disrupt the whole cost structure of the industry. It wouldn't be visible, like an Uber disruption to an entire market, but if we can go to market with a whole different cost position, a whole different service position — that would be very exciting. It requires combining digital and physical technologies to unblock blocked places.
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> It also means building teams in different ways: hiring people with different perspectives and different thinking. It's the Silicon Valley model of bringing in a diverse set of backgrounds to re-look at a problem. They ask, "Have you ever thought of doing X?" "Yeah, we tried a long time ago." "Well, do you know Y exists now that might help?" And you say, "Wow, if that exists then I can open this door. And if I can open this door into a new area, that opens eight more doors." And now I look five steps ahead and I can see a place I never thought was possible. It really allows us to weaponize our data for the market.

"Let's not get too excited," Baglieri protested, "Because Uber is not making money. Everyone is excited over Netflix, but Netflix is not making money. Not all businesses need to be disruptive. And when you change the business model, you need to change the way you interact with customers. The value of all this technology is the ability to continuously re-modulate the service you provide, and to provide to your customers only that which they really need. It's not because of technology that you innovate; it's because of how you re-design the business that generates innovation for your customers."

"How established do 'disruptive' technology companies need to be before you feel comfortable working with them?" Plume asked.

"We actually went through this exercise to figure out when do we engage and whom do we engage," Mahmood responded.

> First, they have to be beyond an angel round: They may not have profitability, but they have cash to burn. What they're looking for is accelerators for growth. Second, they have more than a minimum viable product — they already have a field trial. The technology has actually been tested and proved itself, and now they're working on tweaks to get the commercial model correct.
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> Along with those two elements, what is the underlying technology that they're using to build products? It has to complement what is already out there. If I'm building an analytical tool to run on the edge, on top of an ecosystem of different pieces of equipment, and what they've built only runs in the cloud — well, that's not really going to solve the problem.

"If those three elements check out, then we'll bring them into our incubator program," he concluded.

“What you’re implying is that the value of a more risky, earlier-stage company far outweighs the untapped value of established companies,” Zerby challenged. “Have we really gotten everything out of the established companies? Is the gap really that big?”

“For the problems we are looking at, yes, it is,” Mahmood answered. “We just deployed a program to look at real-time video feeds taken off a drone inside a tank to detect corrosion. The challenge the start-up solved was doing real-time analytics off real-time video, which is a much harder problem to solve. I’m not going to get something like that from any enterprise service provider.”

“We’ve learned in our research that the level of technology competence can vary a lot based on company size,” stated Nico Abbatemarco, Junior Fellow in Information Systems at the SDA Bocconi School of Management. “Small and medium companies often don’t have the money to build competency in a new technology. A large customer, for example in oil & gas, expects digital twins from all its vendors of all its pipelines, and the small suppliers don’t have the digital competence. But if one of the main pillars of Industry 4.0 is integration, then we have to level this part of the value chain.”

“That’s part of why we are more conservative,” Meyer remarked. “Would we be a small vendor’s largest customer? If yes, then no way. Largest or only: Either one of those is no, no. Beyond that, acquisitions are a way to fill the portfolio, if we don’t build it ourselves, we could buy 25-30 person companies.. But we never mess with them, other than to buy them.”

“Our objective is not a potential acquisition, which is a key distinction,” Mahmood allowed. “If you have that appetite, then you should go deep, because you’re really minimizing risk. It’s your level of risk appetite that drives when you engage.”

“Our digital innovation office at Chevron works to create partnerships with small companies,” Williams chimed in.

> Last year the charter was to “go off and create a digital plan,” because — of course — everybody had to have a plan. And as you can imagine, the majority of what came back was very tactical. So this year we stepped back to look at the business outcomes we are trying to achieve, the problems that we are trying to solve.
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> In one major capital project, we identified 31 different issues across nine functional areas. Before, we would have applied different technologies to everything. Now, the companies in our incubator were helpful in driving strategic discussions, in working backwards from the problem at hand to the technical solution. And we’ve identified just five different technologies that we can use to resolve all the issues.

When OT Met IT

“What company functions are participating in Industry 4.0?” Gallant asked.

“At Tetra Pak, we have Development & Engineering, global IM, the service organization, because solutions are under service, and supplier management, because of the different engagement models that we might need,” D’Amato started.

“Also internal manufacturing, supply chain, the packaging group, and the processing group,” her Tetra Pak colleague Meyer added. “So that all includes traditional IT, manufacturing for internal, manufacturing for customer equipment, and the control systems that go with both.”

“For Tenaris, there’s a team in IT responsible for digital,” Lammertyn picked up.

> We had an automation side that worked with manufacturing, and data scientists inside process R&D. Sometimes IT was invited to participate because of cybersecurity, but not at the beginning. Production was looking at automation, but not looking at IT as a provider of digital solutions. In this landscape, no one was in charge of integration, so whoever took the initiative had to deal with the rest.
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> A year ago, we started to shift the model — we set up a combined agenda with automation and data science to prioritize how we use our resources. Now, cybersecurity has to be provided from IT, and it has to be available. On the industrial side, operations are more involved in decisions and processes. From the commercial side, it’s more supply chain. And commercial is trying to develop a digital supply chain, so we need to align the organization to that as well. No one specific person “owns” Industry 4.0. It takes teamwork — it can’t be driven by only one position.

“It’s pretty much the same for everybody,” Beilstein shrugged. “IT, engineering, operations, science & technology, product management. If we’re working on a new product feature or introduction, then the whole value chain is involved — marketing, IT, the whole nine yards.”

“So how are OT and IT playing in this landscape,” Gallant followed up. “Is the relationship between these two organizations changing? How do they come together, or should they even come together?”

Pant described Owens Corning’s approach to the OT/IT question:

> We had a lot of platforms that had degraded over time: There wasn’t a lot of focus on sustainability. Or, we would get a request to do analytics in plant, and have to spend the first two months just cleaning up the data.
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> So, how do we create ownership for new things, and for sustaining what’s already in place, so that when you need either of them, they’re ready to go? We pulled a cross-functional group together, and we quickly found different portfolios that everyone was managing, that weren’t always overlapping, and may not all have been aligned to critical business priorities.

So first we needed to assemble a consolidated manufacturing portfolio, aligned with key business and operations leaders, to make sure we are delivering in the right areas. And with that portfolio, ownership assigned for each of the different strategies, platforms, and products. Who is building what? Who is setting standards? Who is working with the plants, not about technology, but about the problems they are trying to solve?

Then we addressed all of this organizationally. We have product and platform owners, and they can be in either OT or IT, but we have one stack: one platform owner for sensors, one for advanced process control, one for ERP, and so on. Then we have products that span platforms, like asset performance management, or track-and-trace, or quality. Between those products and platforms, they work together as one team, regardless of whom they report to.

We also have a third-party IT partner, and in the hundreds of items in our portfolio, they were often listed as the "owner." They can't be the owner. They can support it, but we put an internal product or platform owner in place for every one, so that if there's an escalation, our partner knows whom to go to.

Finally, we forcefully put in rules to have all platform owners meet together, because all the platforms are interconnected. The product owners work together, because their products overlap with all the platforms. And the full IT/OT team meets face-to-face every quarter, so that we never have any finger-pointing about "That's an OT issue," "No, that's an IT issue." It doesn't matter: This is an advanced manufacturing team, and it includes people who own the products and then platforms. And we supplemented those key owners with a named infrastructure resource, a named cybersecurity resource.

"This has taken the confusion out of whom to go to in order to get something specific done," Pant finished. "We put clarity around roles, and what each role is accountable for. We are six months into this, and everyone is operating differently. Working closely together, there are no surprises. We've taken out the delays and the waste, and not knowing what the right hand and left hand are doing."

"What we're trying to impart to our OT/Engineering side is that IT brings a level of discipline, structure, and lifecycle thinking to what has traditionally been the wild, wild west of applications," Beilstein explained. "On the flip side, IT struggles to realize that everything that happens on the shop floor is deterministic: A signal goes out, and we need a response back in a millisecond, or somebody's life is in danger. The goal is for IT to bring the platform expertise, and OT to know what needs to happen on the shop floor, and the marriage of the two is what makes the difference."

Gallant posed a lightning poll to the group: "Do IT and OT become one organization, or remain as two?" 10 voted No, 4 voted Yes, and 3 answered, "It depends." SDA Bocconi's Brechbühl expressed the view shared across all the answers: "There has to be a mechanism where the two come together, and an identified group of people who make the final decisions. That's different

from a reporting relationship. It's the difference between governance and leadership: One governance structure, and either one or two sets of leaders."

"If you have only one team, there's inefficiency that comes with it, because everybody has to do everything the same way," Zerby explained. "An overlap point is important, but there's also the speed and agility you'll get at the edge when groups can operate independently. If you put things together, they fall to the least common denominator. I'd rather focus on the intersections."

"It doesn't work to have Team X deliver something to Team Y," Meyer countered on the other side of the question. "There are multiple disciplines, and all the disciplines have to be on the same team to deliver a specific governed and approved project."

"It depends," Baglieri adjudicated. "If a company is still focused on manufacturing, all by itself, there's no need to merge IT and OT. If the company acts as an architect including other companies, to become a service provider — then OT has to converge with IT. The answer is based on how you run your business, not on any absolute."

"If we look back in time, OT and IT were able to work more independently without stepping on each other's feet," German summarized.

> But as integration and capabilities start to cross plans and plants and platforms, we are all realizing that the company cannot achieve its goals if people work separately. IT and OT need to come together, because neither one has full information, even on their own systems. Cybersecurity was just the first manifestation of data becoming more federated.
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> Cyber is also the easiest example of cross-functional services that will need to have common governance. For security reasons we are moving all the OT infrastructure into IT's data centers, and IT cybersecurity will serve OT's infrastructure and infosec needs. There's no need in an organization to have two sets of cybersecurity experts.

One Cyber, Indivisible

"The link to cybersecurity was the catalyst for us," Cron stated.

> When WannaCry came out, OT had to know how many computers could be affected, how many HMI devices? And what did they need to do? So they knocked on IT's door and talked to the security guy, and that's where we saw the first natural collaboration to address a customer issue. And from there we're making progress on a number of different topics.
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> Ten years from now the IT role will be very different from today: it will be completely embedded in the business. Of course as part of OT, but also in supply chain and everywhere else. There might still be a standalone organization to give the company a backbone, but it will be more in phase with and linked to the business. People have

started to realize that IT is not there just to run and optimize servers. That's important and needs to be there, but there is so much more to IT.

Gallant pursued the cybersecurity topic: "How is Industry 4.0, and this convergence of IT and OT, changing how you approach cybersecurity?"

"In 2015, we had two people with titles somehow related to security," Meyer answered. "Since then we've built a substantial central governance and operational unit, and we have delivered extensive education and awareness programs throughout the company. Somewhere along that journey Stuxnet hit, which created the awareness that cybersecurity needs to be managed at the factory level as well. We are moving towards one cybersecurity team for the entire company, without regard to whether it's internal IT, OT, or information security."

"We have a robust cybersecurity group," Earls declared. "We've been at it for a long time because of our military business. So for Industry 4.0 we leverage that team. In our projects where we're connecting machines, our data security team is involved to make sure we build the architecture in a secure way. It takes our security up to a whole new level."

"We have a single team, covering all geographies, all countries, all businesses," Zerby added. "They've just formed a sub-team to specialize in manufacturing and security."

"We have the US military as a client as well," Mahmood continued. "Cybersecurity is a single team, that rolls under IT. We also get hired to do cybersecurity assessments for our customers, because to get the class certificate we have to take a laser focus on the processes and make sure they're secure."

"And what are the biggest security concerns right now?" Gallant asked.

The first answers were remote access, open source, insider threats, data spills — the same topics the Roundtable has been discussing for years. New risks based on new technologies followed:

"I'm concerned about data being changed," Brechbühl volunteered. "Not stolen or disappeared, but changed and put back into the system. When so much is driven automatically by data this is a large and growing vulnerability, without even going to the extreme cases of a dam or a hospital."

"Machine learning being taught the wrong things, and using those wrong things to make decisions," Meyer proposed.

"The complexity of the ecosystems in which we operate, and the disruption of those ecosystems," Zerby offered. "If somebody was able to interrupt GPS, or power grids, the internet, wireless, in any meaningful way, it would be debilitating. And there's nothing we could do other than sit here and 'enjoy' it till somebody else solves the problem. That's going to be painful."

The Right to Win

Baglieri posed a provocative question to the Roundtable:

> The US GDP is nearly 80 percent service. In Germany manufacturing is less than 30 percent; in Italy it's less than 25 percent. Our economies are service-driven and yet we still make products. And it seems that even if we make a lot of good products, the value customers perceive is no longer in the good, but in the service. And we have been talking all day about companies doing things to manage and control their architectures, to integrate more fully.

"Will manufacturing stay as we know it, or will we transform our factories in service of other companies?" he asked.

"Well, there are more things manufactured today than there were yesterday," Zerby pointed out. "And what do we now call 'a product?' Do we call Alexa and the service it provides a product? If we do, then there are even more products today than there were yesterday. I don't think we get fewer products, but we do get more shallow value chains. Why do you need a distributor, or even a retailer, if the customer can just print it? I still need materials to put in the printer — I just don't have to go back to some 100-year-old plant in Ohio to get it."

"Isn't this the journey you're on?" Gallant asked Meyer. "You're looking to get into the operations of your customers and run those: 'Outcomes-as-a-service.' Your products become delivery mechanisms for the next generation of your business?"

"Even there, the business of automating their plants is nowhere near the core business that exists for packaging material," Meyer answered. "Yes, it's a service, but it loops around to why we exist in the first place. Milk still needs to get into your hands on-the-go somehow: you can't replace the package with a digital version."

"At the extreme, if you squeeze all the profits out of production into services, then there's no incentive to manufacture anything, and you loop into an absurd situation without any services, either," German suggested.

"But services are instrumental to maintaining the business," D'Amato rebutted. "They're just an investment, a source of cost, to ensure that your market share doesn't shrink. We can dream about an increase in margins and new revenue streams, but the reality is more prosaic."

"We saw a glimpse of this in oil & gas, where the value chain began to shrink, but because of market forces, not because of innovation," Mahmood recalled.

> When the price of oil tanked, manufacturing companies bought service companies, and service companies bought manufacturing companies, because the objective became to provide a turnkey solution.
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> It makes me wonder if at some point your product simply becomes your right to play, and not your right to win anymore. Today, product innovation is a competitive

> advantage, but if you shift your competitive advantage to services, does your product start to become stale? Services tied to manufacturing are powered by software portfolios. Call them digital enablers. Within that element, how do you commercialize those service packages? They are completely different commercial models than what we have been using.
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> So when OT and IT converge it's because IT is getting pulled to the commercial side, and OT is getting pushed towards IT. It makes sense to have them as a single protocol — and the contribution is now going to be more towards the revenue side than the cost-cutting side.

"The commercial structure for how to take these services to market and make them profitable?" Mahmood finished. "That is a sweet spot for a tech company, but not for a manufacturing company. It is uncharted territory for many of our firms."

"Maybe the biggest takeaway from today is that change is going to be hard," Hinchcliffe suggested.

> We still have so much variability in our organizations. There's too much friction in the value chain: Systems that don't talk to each other, processes that don't integrate, experiences that don't interact well together. We have to change this technology, and at the same time figure out how to get people to change with it, because collaboration is going to become critical. And at the same time as everything becomes digitized, everything also has to become de-centralized, because centralization becomes a bottleneck.

"Where is all this digital transformation really going to take our businesses?" Hinchcliffe asked in closing.

> Is it just going to be never-ending optimization? Or is it really going to allow us to re-invent what our companies do, in fundamentally new and exciting ways, that are going to thrill our customers and grow our businesses? We have to try more experiments, so that we can find the path forward before the start-ups do, before our competitors do. We don't currently have a clear path towards disruptive innovation, and without that clear line of sight, the implications are existential.

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