The Digital Twin

Compressing time-to-value for digital industrial companies

The Industrial Internet holds great promise for industrial companies worldwide. As organizations progress toward digitization, their time-to-value can be compressed by leveraging successful patterns used today by consumer Internet trailblazers like Amazon, Apple, and Google.

This paper examines the concept of digital twins—dynamic digital representations that enable companies to understand, predict, and optimize the performance of their machines and their business. Digital twins exist at the nexus of physical engineering, data science, and machine learning, and their value translates directly to measurable business outcomes—reduced asset downtime and maintenance costs, improved plant and factory efficiency, reduced cycle times, and increased market agility.
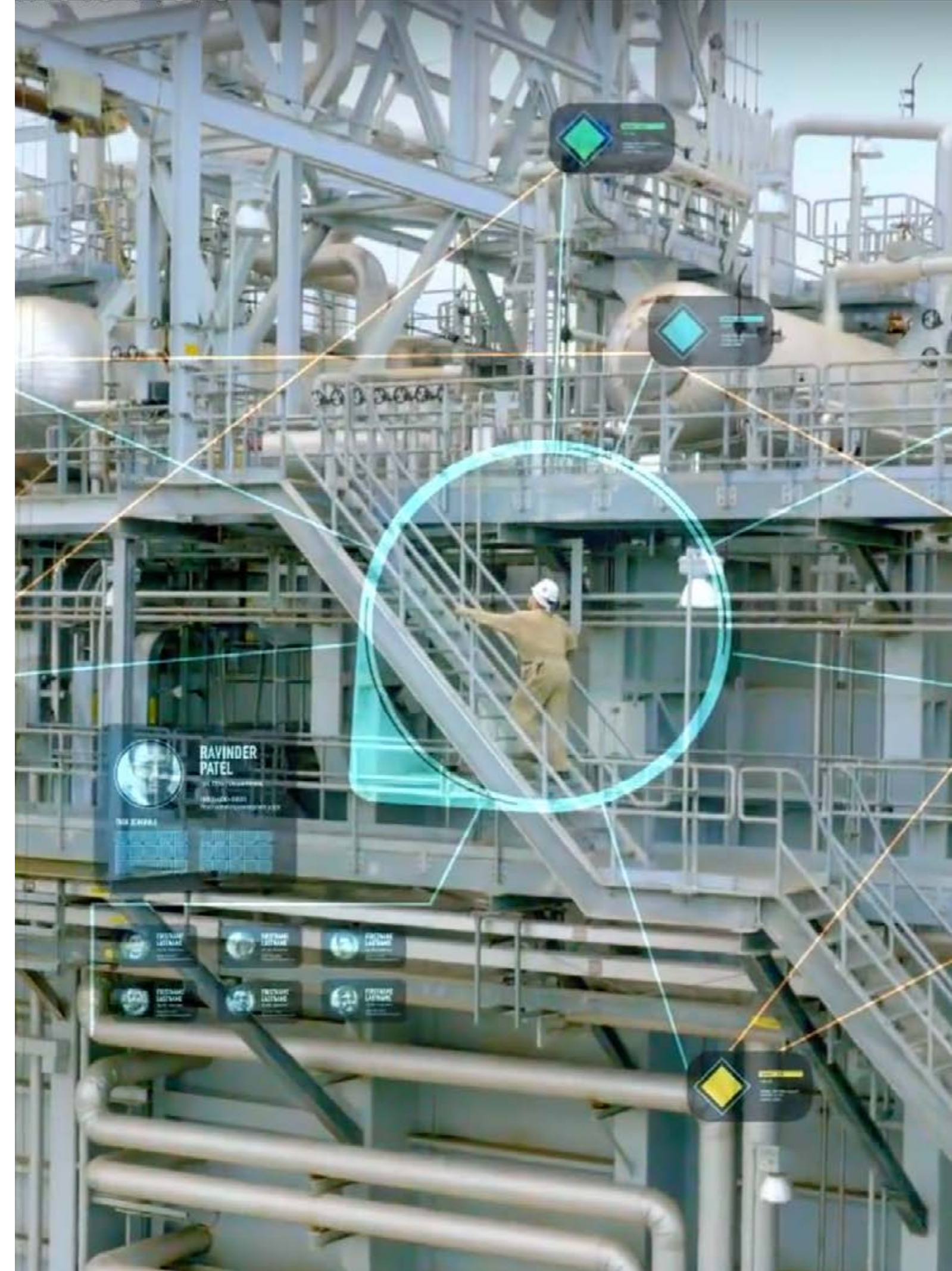
The power of one

Consider the meteoric growth of consumer Internet brands like Amazon, Apple, and Google. Amazon grew from startup to $89 billion in annual revenue in 21 years. Google grew from startup to $66 billion in revenue in 17 years. Apple increased annual revenue from $8 billion in 2004 to $183 billion in 2014.

Leading consumer Internet brands began their market-facing journeys using coarse-grained demographic models to address buyer audiences. Over time, as they expanded into new markets, consumer Internet leaders also systematically enriched buyer demographic data with preference data derived from individual buyer behaviors—products frequently purchased in combination, responses to promotional offers, views of comparable products—to name a few. By collecting and analyzing detailed behavioral data, consumer Internet brands evolved from coarse-grained demographic views—which modeled large populations of consumers— to a model specific to each consumer. Further supplemented by advanced data science that pinpoints group affinities and behavioral causalities, consumer Internet brands now precisely target buyers by addressing each as a "market of one."

"So far, attention has been focused on the consumer Internet, where connected products have already transformed the way we live: from shopping to moving around town, from managing our home systems to organizing a holiday. But now the spotlight is shifting to industry, because this is where the biggest transformation is taking place—and where the greatest value will be created over the coming decade."

Dr. Marco Annunziata, Chief Economist, GE

Digital twins require massive computing scale

By combining data and advanced data science, consumer Internet leaders build a digital twin—a digital model representing deep profile characteristics—of every target consumer. And every time a consumer reads a product review, views a complementary product offer, or purchases a gift, that buyer's digital twin gains additional resolution. Thus, the digital twin of each target buyer is continuously improved over its lifetime.

To build and enrich the digital profiles of hundreds of millions of individuals, consumer Internet leaders have created massively scalable cloud infrastructures consisting of millions of physical servers. They harden their infrastructures by removing all unnecessary software, implementing advanced security protocols, and even deploying hardware specifically tuned to their cloud technology stacks. The skill and financial resources needed to operate these distributed, massively scalable compute and storage infrastructures are beyond the reach of all but a small number of companies.

Digital twins for the Industrial Internet

What can Industrial Internet companies learn from consumer Internet trailblazers? They can learn to require secure, hardened platforms; to focus on data and intelligence; and to apply digital twin patterns to obtain high-fidelity digital representation of their systems.

Consider a combined-cycle power plant that uses a natural gas–powered turbine as its primary electricity generator, and a steam turbine that uses the byproduct of gas-fired production (i.e., steam) as its secondary generator. Turbines comprise thousands of components, each of which is subject to failure based on metallurgy, load, environment, and other factors. It is impossible to pinpoint the proper time to take a turbine offline for maintenance using traditional mean time between failure (MTBF) estimates. So plant operators have no choice but to schedule expensive—often unnecessary—maintenance cycles based on historical operating experience and the "tribal knowledge" of a few expert employees. Even with scheduled maintenance, operators have no ability to predict when turbine assemblies will fail, exposing the entire plant to the risk of unscheduled outages.

Apply digital twin patterns to this problem, however, and the outcomes change dramatically. Sensors installed on critical turbine assemblies transmit real-time data to a secure computing resource, building a digital twin of each component and assembly. The digital models are enriched with situational data such as system load, ambient temperature, and air quality.

By building a digital twin "model of one" for every critical turbine assembly, and continuously analyzing each model using advanced statistical tools, plant operators can bring turbines down for maintenance predictively, eliminating the costs of unnecessary downtime and mitigating the risks of unplanned outages.
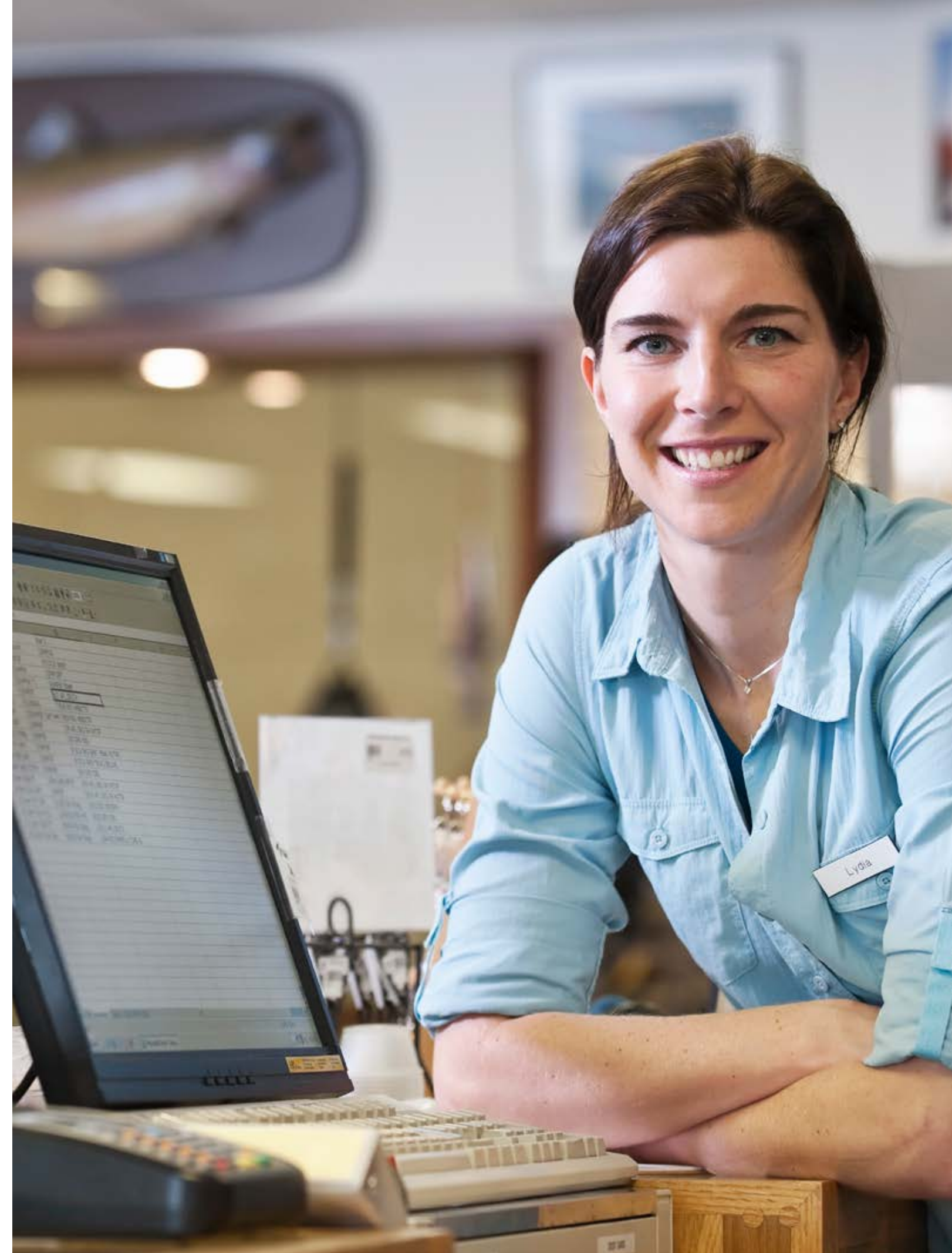
Physical science + data science + learning system = velocity

Unlike the consumer Internet, which relies on human behaviors to build digital twin models, industrial companies have amassed decades of physical science about their products, equipment assets, manufacturing processes, and operator control systems. This science forms the ready-made scaffolding of a digital twin, which is then brought to life with data collected by sensors onboard the physical assets. By applying advanced analytics and machine learning to rich, continuously improving asset models, digital twins gain enough resolution to drive important business outcomes—asset optimization, manufacturing efficiency, and machine operator intelligence.

To converge physical science and data science, however, Industrial Internet companies need a massive, hardened computing platform—rivalling the scale of the infrastructures used by consumer Internet leaders. They also need an ecosystem of stakeholders that will collectively deliver the analytic intelligence to improve digital twin models and drive business outcomes over a horizon of several decades.

"Like GE, Pitney Bowes is in the midst of its own physical and digital transformation. With APM apps running on the Predix platform, we're able to extract and analyze data from our assets faster than ever, and use that insight to drive real business outcomes for Pitney Bowes and its clients. GE knows industrial machines and related data analytics better than anyone."

Roger Pilc, Chief Innovation Officer, Pitney Bowes
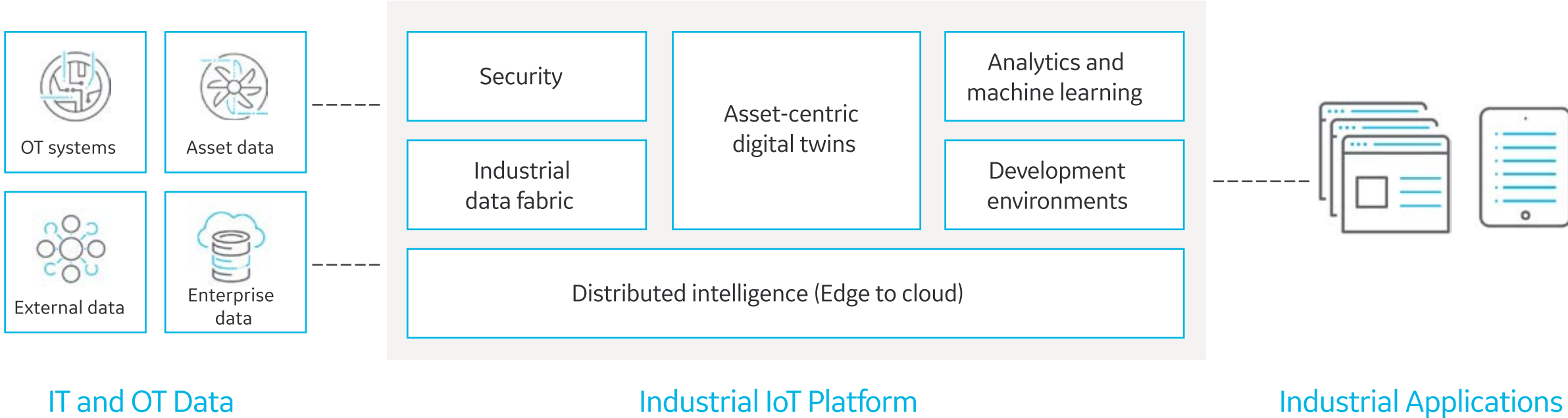
GE Digital's Industrial Internet leadership

Just as the consumer Internet giants drove adoption and growth by using digital twins to anticipate buyer needs, GE is using data, analytics, and learning systems to predict the future behavior of the critical infrastructure that underpins the modern world—including energy, transportation, manufacturing, and healthcare. We uniquely bring the financial resources and market reach needed to shape the digital industrial landscape. Our leadership spans many markets and geographies, and we extensively leverage the Predix industrial cloud platform to deliver a growing portfolio of Industrial Internet solutions.

GE's Predix Platform

Predix Platform, the world's first Industrial Internet platform, is reshaping the companies that shape our world by connecting data, intelligence, and people. Predix Platform provides tools for building and managing digital twins and their associated analytic models to make it easier for organizations to leverage advanced analytics to model, analyze, and optimize their assets, operations, and business. It's designed from the bottom up to tackle the unique challenges of industrial computing, supporting deployments anywhere from the edge to the cloud, and protecting them with built-in security and governance. All this is supported by a software ecosystem that makes building and using applications faster, shortening time-to-value. The future of industry is here, and it runs on Predix Platform.

"GE is truly on the path to digital transformation. With the announcement of GE Digital as a separate software division, Predix as platform-as-a-service in the cloud, and ready-to-roll asset performance management, this manufacturing company is evolving. The company has all the elements of digital transformation that IDC believes are essential to success. A commitment from ledership, a reworking of the operating models, a focus on information, and a refreshing view toward sourcing work with partners and developers are in the mix."

Robert Parker, Senior Vice President, IDC

| OT systems | Asset data |
| External data | Enterprise data |

Security	Asset-centric digital twins	Analytics and machine learning
Industrial data fabric		Development environments
Distributed intelligence (Edge to cloud)		

IT and OT Data

Industrial IoT Platform

Industrial Applications

Building digital twins

GE Digital's data scientists are working aggressively with engineers across GE businesses to build digital twins for our industrial assets and manufacturing processes. Those digital representations allow us to deliver better products, operate our own plants with greater efficiency, and provide better service to our customers. Said differently, we are running our business using the same digital models, tools, and patterns we believe will be used by all industrial leaders.

We are also making our digital twins available to customers and partners out of the box with our Predix platform, enabling them with additional analytics that fuel growth further across their own value chains.

Industrial business applications

GE Digital provides comprehensive application suites aimed at helping industrial companies reduce maintenance costs, streamline manufacturing processes, and improve operator performance.

- Predix Asset Performance Management (Predix APM) is a suite of software and service solutions designed to help optimize the performance of your assets. Predix APM increases asset reliability and availability while optimizing maintenance costs, mitigating operational risks, and reducing total cost of ownership (TCO).

- GE Digital's Manufacturing Solutions software is the synthesis of more than two decades of working with the world's most recognized brands in manufacturing and our own GE plants. Our software enables you to predict, adapt, and react more quickly and effectively than ever before.

- HMI and SCADA products use real-time digital twin models to help operators in manufacturing and infrastructure industries implement intelligent control applications.

Professional services

GE Digital and our partners offer a range of professional services to assist you at every point in your Industrial Internet journey.

- **Advisory services** provide guidance, acceleration and scale to your Industrial Internet initiatives. Our IIoT Workshops inspire outcome-driven thinking and sharpen your team's analytic strategy.

- **Managed services** provide remote monitoring and diagnostics for industrial operations requiring real-time response, extensively leveraging GE Digital's predictive analytics solutions.

- **Acceleration Plans** offer a comprehensive set of service capabilities to help you maximize value from your software investments and capitalize on your digital industrial transformation.

Industrial Internet innovator, partner, and collaborator

Several years ago, we embarked on a journey to transform GE plants and factories into digital industrial leaders. We are now collaborating with customers and partners to drive positive changes across the industrial landscape.

We are also making our asset models available to customers and partners as baselines, enabling them to accelerate the delivery of analytics that fuel growth across their own value chains.

"GE Digital's Manufacturing Solutions has enabled significant reductions in unplanned machine downtime, resulting in higher plant efficiency. As part of our Digital Thread strategy, we will increase our machines and materials connectivity by 400% in the coming year."

Bryce Poland, Advanced Manufacturing Brilliant Factory Leader, GE Transportation

Summary

The Industrial Internet holds great promise for industrial companies and their customers worldwide. Time-to-value can be compressed by leveraging the successful patterns in use by consumer Internet trailblazers. Those patterns reveal a journey that began with simple demographic models and is evolving to describe a detailed model of individual consumer characteristics, preferences, and behavior—the digital twin.

Digital industrial leaders are aggressively applying the digital twin concept—leveraging engineering, scientific knowledge amassed over decades, and machine learning—to build digital models of a wide range of equipment assets and manufacturing processes. Continuously gaining resolution, these models are the fuel that powers advanced analytic applications which, in turn, deliver insights that enable important business outcomes—reduced asset downtime and maintenance costs, improved plant and factory efficiency, reduced cycle times, and increased market agility.
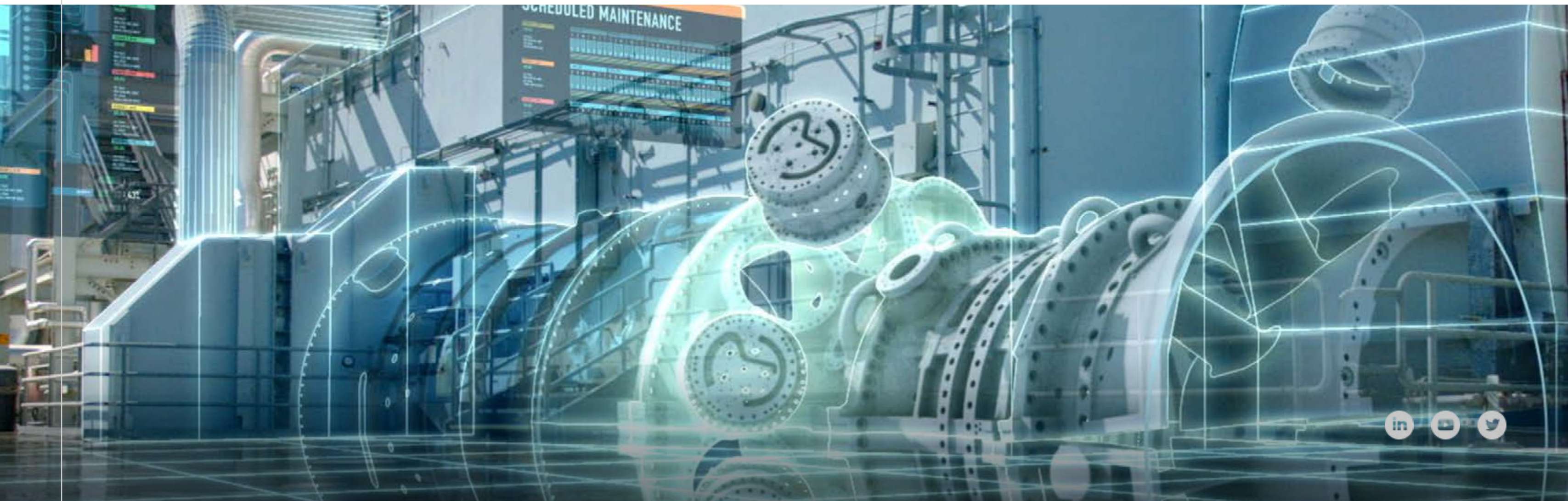
Related Resources:

The Moment for Industry
Marco Annunziata, Chief Economist, GE

Industrial Internet: Pushing the Boundaries of Minds and Machines
Peter C. Evans and Marco Annunziata

About GE

GE (NYSE: GE) is the world's Digital Industrial Company, transforming industry with software-defined machines and solutions that are connected, responsive and predictive. GE is organized around a global exchange of knowledge, the "GE Store," through which each business shares and accesses the same technology, markets, structure, and intellect. Each invention further fuels innovation and application across our industrial sectors. With people, services, technology and scale, GE delivers better outcomes for customers by speaking the language of industry.

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