PREDIX
The Industrial IoT Application Platform
Table of Contents

Executive summary ....................................................... 4

IIoT and the digital transformation opportunity ......................... 4
  Digital transformation requires new thinking and new technology ....... 5
  Application development and deployment remains a daunting task ......... 6
  Selecting an industrial application platform ................................ 6

Predix Platform: the Industrial IoT application platform ................. 7
  Purpose built for industry .................................................. 7
  Enabling distributed intelligence ........................................... 8
  One platform delivering multiple outcomes ................................ 9

Predix Edge: building operational intelligence ............................. 10
  Building smart devices ..................................................... 10
  Connect to assets and data of any vendor or vintage ...................... 11
  Predix data at the edge .................................................... 11
  Manage the device lifecycle ............................................... 11

Predix Cloud: delivering essential industrial services .................... 12
  Microservices architecture ................................................ 12
  Core industrial services ................................................... 12
  Flexible deployment ......................................................... 13
  Connectivity ................................................................. 13
  Asset models ............................................................... 13
  Digital twins: a single source of truth ................................... 14
  Industrial big data fabric .................................................. 15
  Data integration builds context .......................................... 15
  Analytics and machine learning ......................................... 16
  Mobility and the digital worker ......................................... 17
  Geospatial intelligence for enhanced insights ............................ 18
Build and run applications: developing smarter to innovate faster .......... 19
   High productivity development .................................................. 19
   Automate the plumbing: solving the data integration challenge for IIoT .... 19
   Simplify IIoT development through reusable services ......................... 19
   High control development ............................................................ 20

Industrial-grade cyber security: building end-to-end trust ...................... 21
   Multi-layered protection ................................................................. 22
   Secure platform and apps ............................................................. 23
   Governance, compliance, and certification ....................................... 23
   Business continuity plan ............................................................... 23
   Data retention and deletion .......................................................... 23
   Continuous monitoring and incident response .................................. 23

Application Spotlight: Predix Asset Performance Management .................. 24

Growing the ecosystem together ...................................................... 25

Why choose GE .............................................................................. 25

To learn more ................................................................................. 26

Appendix A: Predix Platform Security Governance and Certification .......... 27
**Executive summary**

**Digital, data-driven services** promise to transform industrial operations with innovations in productivity and efficiency. In a recent report, 85% of IT and OT decision makers recognize these benefits with many adopting new and/or disruptive technologies within their business. This includes embedded sensors, big data, cloud, analytics, and digital twins.

Yet only 13% surveyed has a mature digital industrial transformation plan in place. Leading digital industrial companies, however, have learned that platform adoption can enable them to manage this highly disruptive change and enable the digital industrial transformation opportunity.

But not all platforms are the same. GE has packaged its broad industry experience into comprehensive Industrial Internet of the Things (IIoT) platform, Predix Platform. Predix Platform is purpose-built for deriving specific industrial insights and outcomes across diverse and highly regulated industrial markets. Rather than taking on the entire burden, companies can now use Predix Platform to build applications on its sophisticated infrastructure, and draw on the lessons learned from deploying the platform within its own manufacturing and IT operations.

**Key attributes of the Predix Platform**

- Built around an **asset-centric digital twin**, creating actionable insights from asset data and analytics
- Provides a comprehensive **edge-to-cloud architecture** that optimizes workloads across varying operating infrastructure
- Supports **high control and high productivity** development to support industrial developers and subject matter experts
- Runs SaaS applications such as **Predix Asset Performance Management (Predix APM)** that increases asset reliability and availability
- The result of **GE’s billion+ dollar investment** in its own digital transformation

Predix Platform equips industrial organizations with everything they need to rapidly build, securely deploy, and effectively run IIoT applications from edge to cloud, turning asset data into actionable insights.

---

**IIoT and the digital transformation opportunity**

**Borne from the IIoT opportunity**, digital transformation for industries such as power, oil and gas, aviation and transportation is about extracting additional value from a companies’ operations. By harnessing data from physical assets and plants, an organization can derive operational benefits. These benefits include gains in operational insights and increased team collaboration, leading to process improvements, cost savings, product enhancements and new data-rich, digital services. This follows the broader digital transformation trend in which companies are adopting disruptive technologies—like the rapid explosion in sensors together with ultra-low-cost connectivity, storage and processing,

---


---
integrated within an IoT platform—that change the way companies operate and deliver services.

IIoT is estimated to be as large as $14.2 trillion to the global GDP by 2030. However, the evolution of digital transformation within industrial markets remains slow. Based on a recent research study of 250 IT and OT decision makers conducted by GE, it was evident that while the potential for IIoT is very strong among industry executives, scoring 78.3 (out of 100), company readiness significantly lags, scoring 55.2 (out of 100). This disconnect between outlook and company readiness presents both a challenge and opportunity for companies seeking to benefit from IIoT.

The benefits of IIoT and digital industrial transformation are widely recognized among IT and OT decision makers (ITDM/OTDMs), but will take time to realize potential.

Digital transformation requires new thinking and new technology

Even the most established and well-run companies often underestimate the challenges involved in transitioning towards digital transformation. Most struggle because they misjudge the complexity, pervasiveness, and organizational impact of the challenge, such as duplicated operational technology (OT) and information technology (IT) systems, as well as the technology needed to underpin that shift. Many industrial organizations need to leverage the massive amount of data being generated by assets as well as OT (SCADA, Historian), IT (CRM, ERP), and external (location, weather) systems. However, operationalizing this data within an application remains a challenge.

It’s important to also consider:

- Industrial data generated by sensors embedded within assets is growing twice as fast as any other sector. Yet today, less than 3% of that data is tagged and used in a meaningful fashion.
- Once collected, these massive datasets are frequently fragmented and siloed into repositories and systems limiting usage elsewhere.
- The data remains largely unexplored as business outcomes are ill-defined. Reading the data for analysis is a laborious and time-consuming process, and data science projects lack asset-centric analytics to derive the data’s true value.
- Existing applications may be too old or monolithic, restricting usage of the industrial

---


3 The overall index and sub-indices are scored from 0-100, with 0 indication a lack of readiness to transform and 100 indicating complete transformation.

4 GE estimates
data. Adding functionality for new users such as plant operators requires extensive re-programming that can take years, and integration with other applications or systems involves external services that make it cost prohibitive.

- Cloud-based applications cannot always accommodate local operating requirements, potentially exposing asset operators to unscheduled downtime and safety events.
- Diverse software development practices can lead to performance variability across different parts of the organization.

### Application development and deployment remains a daunting task

The barrier to entry remains high for building Industrial-grade applications in large part due to the complexities of data integration and management. Gartner estimates that 75% of IIoT application projects will take twice as long as expected due primarily to challenges related to the underlying data of an application. In fact, research has shown that approximately 60% of a data analytics projects budget is associated with data integration, and half of those projects will either fail or go over budget.

Unlike other industries, the challenges faced by industrial enterprises are unique as the talent required to solve these challenges is highly specialized. For example, take a maintenance engineer that deals exclusively with gas turbines. They have deep tribal knowledge in the turbine that they may have serviced for decades. Capturing that unique and valuable knowledge in a pervasive manner allows an organization to reuse and extend it for new turbines being brought online. That’s why establishing an application platform within the business that is flexible, scalable, and reusable across a variety of use cases is critical.

### Selecting an industrial application platform

From connecting machinery or sensors at the edge and performing local analysis, to storing, securing, and analyzing the data in the cloud, an IIoT platform plays an important role. Many features and functions can be shared across various applications. Inevitably, each application must produce differentiating insights via contextually relevant analytics, used by various stakeholders across operations, IT, and the business.

Key platform requirements include:

- **Asset-centric** – build then expand the asset model to include assembly lines and factories, or vehicles and fleets of vehicles; report and initiate actions at the asset and sensor level; exploit asset knowledge as reusable machine learning

- **Edge-to-cloud** – intelligent system that spans edge, on-premises, and cloud; supports a variety of deployment options based on available hardware resources; integrated together or used independently to optimize workload execution

- **Distributed architecture** – support varying architectures; centralizes big data processing in the cloud to take advantage of compute and storage; performs data analysis at the edge, close to the device, to support latency and bandwidth constraints

- **Data fabric and data management** – ingest multi-terabyte streams of time series data from assets located in harsh and distributed physical environments; support big data processing frameworks such as Spark; deploy analytics to operational data in motion

- **Insightful analytics** – react rapidly to incoming data; explore and exploit historical data for insights; evolve asset-centric digital twin models

---


of assets and systems; better predict asset health and performance using machine learning

- **Flexibility and extensibility** – integrate with a variety of assets, industrial controls systems, and data; rapidly create and extend applications without the costs and risks of integrating separate modules; support deployment options to meet varying needs

- **Embedded cyber security** – so developers don’t have to build it in as an after-thought; support various industry standards and governance whilst adhering to data retention policies; continuous monitoring for availability, safety, and compliance

- **Ecosystem oriented** – tap into a network of experienced, certified practitioners, such as system integrators and ISVs; speed innovation by leveraging others domain expertise, applications, and services; open to support different markets and business outcomes

That’s why GE built Predix Platform. Based on decades of industrial experience, GE recognized common themes in the emerging digital transformation movement, and designed an application platform that targets industrial use cases. Specifically, the platform supports innovative applications and analytics that turn real-time operational data into actionable insights. Predix Platform equips customers with the tools they need to rapidly build, securely deploy, and effectively operate industrial applications.

### Predix Platform: the Industrial IoT application platform

Predix Platform is the distributed application and services platform for building and running powerful digital industrial solutions. The platform connects data from physical assets to powerful analytics and industrial applications, such as Predix APM ([see Spotlight section for more on Predix APM](#)), to improve operations, lower costs, and develop and monetize new data-driven services.

[Diagram: OT systems, Asset data, External data, Enterprise data, Security, Asset-centric digital twins, Analytics and machine learning, Development environments, Distributed intelligence (Edge to cloud), IT and OT Data, Industrial IoT Platform, Industrial Applications]

*Predix Platform is built around an asset-centric digital twin, which differentiates the platform from others.*

### Purpose built for industry

Predix Platform incorporates decades of operational domain expertise as essential industrial capabilities that are specifically designed for the unique requirements of industrial companies:

- **Distributed intelligence** – A cloud and edge technology stack that work together to support complex, distributed applications and analytics

- **Asset connectivity and management** – Collect, process, and securely transfer data from assets to analytics and applications in the cloud
• **Digital twins** – Software-based, dynamic digital representations of physical assets and systems that take advantage of industrial-grade analytics to model and optimize real-word assets

• **Analytics and machine learning** – Rich, robust, industrial-grade analytics capabilities that generates insights across the entire life cycle of industrial assets

• **Big data fabric** – Flexible options for ingestion, analytics execution, and storage for streaming and big data processing

• **Security** – Stringent security measures that are designed into the fabric of the platform, forming a continuously monitored, protected platform for operators and developers to secure industrial innovation

• **Application development and extensions** – Application development environments that support high productivity (4GL, low code environment) and high control (full stack development)

**Enabling distributed intelligence**

Industrial operations are often located in harsh environments. And for many companies, connecting to remote assets and securely transferring operational data remains a significant challenge. As a distributed application platform, Predix Platform provides a deployment architecture that spans cloud, on-premises, and edge. Edge-to-cloud deployment models are complementary and typical industrial applications need both in order to maximize insights.

Edge computing addresses the limitations of a cloud-only deployment model and addresses the following use cases:

• **Reduced latency** for mission-critical control systems and applications that must execute near the asset

• **Governance or regulatory compliance** where data cannot leave the premises, locality, or otherwise be in proximity to certain data or people

• **Bandwidth and network costs** where compute is more economical at the edge

Comprised of two complimentary software stacks—one for edge computing and one for cloud computing—these stacks work together to optimize workload execution using a variety of deployment options: on an intelligent connected asset, controller, gateway, edge server, or in the cloud. When used together, Predix Platform enables data ingestion, analysis, intelligence gathering, and control at the place where it’s needed.

*Predix Platform services can be executed across edge and cloud to optimize workload execution*
One platform delivering multiple outcomes
GE has invested in building capabilities that can deliver outcomes across many different industries.

These outcomes range from the reduction of unplanned downtime to improved asset output and operational efficiency. Companies can also create differentiated services that generate new sources of revenue.

1 Scheduling & Logistics
Increase asset utilization with predictive analytics, improving performance, and efficiency that can result in lower repair costs.

2 Connected Products
Replace the current “break-fix” model with a “predict-and-prevent” services approach by making machines software defined.

3 Intelligent Environments
Tap into LED solutions and sensors in cities and buildings to collect and analyze data and enhance everyone’s experience.

4 Field Service Management
Give workers the machine data, expertise, and processes they need to schedule work orders, make repairs and upgrades more effective.

5 Industrial Analytics
Monitor asset health to identify problems, then use predictive and prescriptive analytics to boost productivity.

6 Asset Performance Management
Achieve new levels of performance, reliability, and availability throughout the life cycle of all assets (See Spotlight section)

7 Operations Optimization
Use key insights on an enterprise-wide scale to resolve operational issues, drive productivity, and increase efficiencies.
Predix Edge: building operational intelligence

Unreliable connectivity, lack of control, the high cost of moving large volume of data, managing thousands of devices, and meeting industry regulations are challenges that Predix Platform addresses. However, merely aggregating and filtering data prior to sending to the cloud isn’t enough. Predix Edge technology enables applications, analytics, and services to execute close to the source of data, such as industrial assets or historians. This close proximity to the data offers a more intelligent methodology to analysis and decision-making than a ‘cloud-only’ approach.

Building smart devices

Predix Machine powers the Predix Edge technology’s ability to run workloads in close proximity to assets and data. Typically embedded as a software-stack within an intelligent device, Predix Machine can run on a wide variety of hardware. It also provides security, certificate management, authentication, and governance services.

**Connect to assets and data of any vendor or vintage**

A Predix-enabled device bi-directionally connects to industrial assets to collect data and send control event/signals. It includes support for OPC-UA, Modbus TCP and MQTT protocols and can be extended using an SDK to support proprietary ones. Predix Platform also supports connections to historians and control systems. Direct-to-storage ingestion options are supported in the Predix Cloud for historian, time-series, and blob data.

Process data at the edge

Predix Platform incorporates a complex event processing (CEP) and machine learning engine at the edge. Analytics can be authored in the cloud then deployed using Predix Edge Manager—enabling low-latency applications and analytics execution at the edge while reducing data and bandwidth costs. When applied to data at the edge, operational analytics ensure the efficient operation of assets by detecting and acting upon anomalies. Those analytics can be improved over time based on historical analysis in the cloud to direct prescriptive controls and signal predictive maintenance alerts.

Manage the device lifecycle

Predix Edge Manager is a cloud-based application that provides a single-pane view to manage the lifecycle of edge devices and edge applications. It allows fleet operators to manage a single or entire fleet of Predix-enabled devices, as well as the apps,
analytics, and configuration files deployed on those devices. The benefits of Predix Edge Manager include:

- **Scalable device management** – Centralized lifecycle management of thousands of edge devices from anywhere, anytime.
- **Reliability and manageability** – Optimize deploying and updating of software and applications.

- **Better, faster operational insights** – Allow operations teams to track, manage, and communicate with all edge devices enabling quick decisions about performance, availability, and alert assignment.

**Application and Software Lifecycle Management**
Deploy, install, and update software and application
Schedule deployment and command execution for multiple devices
Receive and disposition alerts from edge devices
Create custom commands
Debug devices by accessing device log files

**Device Lifecycle Management**
Securely commission or decommission devices
Perform device configuration
Create and administer device groups
Search and filter device lists based on attributes of interest
Monitor device health, settings, and history

**Connectivity Management**
Configure secure connectivity and communication with edge
Manage device’s VPN connections
Manage SIM connection
Monitor network and data usage (if on cellular network)

**Device Lifecycle Management**
Manage authorized users
Assign roles and responsibilities
Assign alerts to technicians for action
Predix Cloud: delivering essential industrial services

Predix Platform is a multi-tenant secure platform optimized for industrial workloads. Predix Cloud provides hyper-scale elasticity, mission-critical availability, and security support for data at rest and in motion. Predix Cloud can handle vast amounts of Industrial Internet information, while also managing customer SLAs, security, support, governance, compliance, and export controls.

Key elements of Predix Cloud include scalable, public-cloud infrastructure abstraction and automation, core platform-as-a-service components, robust data fabric layer and a defined set of runtime, storage, and development services.

Microservices architecture

Predix Platform employs a microservices-based architecture that supports a modular approach to developing applications. Microservices deliver functionality as granular building blocks, allowing developers to quickly build, test, deploy, and—most importantly—scale applications. Microservices are also great enablers for continuous delivery, allowing frequent releases for users while keeping the rest of the system available and stable. Once apps are deployed, updates are much simpler and more efficient, eliminating code recompilation and streamlining operations.

Core industrial services

Predix Platform provides a rich set of industrial services for building, testing, running, and managing IIoT applications. These core services are provided as microservices and offer functionality in the following areas:

- **Asset** – Services to create, import, and organize asset models and their associated attributes
- **Data** – Big data infrastructure that includes integration, data ingestion, data processing, machine learning, data modeling, data visualization, and tenant-based encrypted data stores
• **Analytics** – Services to create, catalog, and orchestrate analytics that will serve as the basis for applications to create insights about industrial assets

• **Application security** – Services to meet end-to-end security requirements, including authentication and authorization

• **Visualization/UI** – Services to build browser-based and native mobile device user interfaces

Predix Platform also provides a catalog of pre-built industrial microservices available from GE and third party partners. Developers can gain access to the platform ecosystem and a library of microservices available for application development and deployment.

**Connectivity**

The design and initial deployment of connectivity services can be complex and lengthy. Predix Connectivity services can eliminate the long lead times and expense of designing and operating a custom connectivity infrastructure.

Predix Connectivity offers seamless, secure, and reliable end-to-end communication between Predix Edge devices and Predix Cloud over various access networks, including fixed line, cellular, and satellite communication.

This allows customers to securely connect existing infrastructure—and new deployments—to the cloud for data ingestion, running analytics, remote device monitoring, and management.

**Asset models**

Asset models are central to Predix Platform. It is how data is collected and organized to create a comprehensive and contextual digital view of the asset that can be used for monitoring, analysis and predictions? Predix Platform asset model provides a unified construct to turn asset data into intelligence, which can be utilized across multiple systems and applications—helping to drive differentiation.

Predix Platform asset service enables developers to create, store, and manage asset models that define asset properties, as well as hierarchical and network relationships (parent, child, peer, etc.) between assets and other modeling elements. Asset models are useful as they describe the structure of subsystems, subassemblies, and components of a unique asset. Asset models typically employ common elements. For example, classifications support different ways to identify and search for assets, which can provide a richer view the asset lifecycle within the business and who needs access.
The Predix Platform asset model is extensible, allowing developers to create custom modeling objects that meet their own unique environment. The asset model can be reused through digital twin technology, providing a single source of truth about the asset.

**Digital twins: a single source of truth**

Digital twins are digital representations of physical assets and systems that enable companies to understand, predict, and optimize the performance of each unique asset. A digital twin can represent a component, a functional asset, an integrated system of assets, or a fleet of assets (e.g., a blade in a jet engine, a jet engine, an entire airplane, or a fleet of planes, respectively). The level of representation is determined by the targeted business outcomes, e.g., reducing unplanned downtime of a compressor compared to optimizing airline fleet schedules.

A digital twin has three major elements:

- **Asset model** that describes the structure of subsystems, subassemblies, and components, often expressed as a hierarchy (e.g., in a turbine) or a network (e.g., in an electrical grid)
- **Analytics** that predict, describe, and prescribe the behavior of the asset, as well as enable automated behaviors that allow twins to control assets, including physics and machine learning models
- **Knowledge base** of data sources and derived insights. This knowledge typically includes time-series sensor data and other asset data, such as work orders and design specifications, as well as inferred relationships between types of data (e.g., between sensor data and work orders)

Digital twins running on Predix Platform build on the asset model. They become a single source of truth for all information related to an asset, including data about past and present state, condition, and performance. In addition, early warnings and prediction could utilize not only the individual data, but also data from similar digital twins—leveraging the power of the platform. Digital twin industrial use cases typically target maintenance and equipment health, predictive maintenance, and operations and performance optimization.

Take an aviation use case that uses digital twin technology to generate predictive insights to aid aircraft landing gear performance. The application continuously compares actual data with predicted data based on the digital twin (defined via the Predix Platform Asset service and Predix Platform Time Series service). For example, actual brake pad temperature is compared against brake pad temperature threshold. Deviations from normal operations can be used to modify and continuously optimize prediction models for required maintenance intervals and catch outlier problems when they are minimal so proactive maintenance can be scheduled.

Each flight delay costs the airline between $25,000 and $40,000. With the digital twin, current landing gear issues can be diagnosed and the remaining useful life can be based on historical data.
For asset manufacturers and asset operators, Predix Platform digital twins offer a unique, highly accurate digital representation of their assets and systems across the design, build, run, operate and service lifecycle, removing barriers to insight and innovation.

**Industrial big data fabric**
Data in the industrial world is growing faster than any other sector, yet less than 3% of that data is tagged and used in a meaningful way. Industrial data is also messier and moves at greater speed than enterprise data—arriving as multi-terabyte streams in different formats and from multiple sources such as equipment sensors, assets, and control systems. Furthermore, data is captured in repositories and systems that are typically siloed, making it difficult to analyze and reuse.

Predix Platform features an industrial-grade data fabric encompassing data ingestion, big data processing, and flexible storage. It supports ingestion of virtually any streaming or batch data source; execution of streaming/batch analytics and workloads using standard, in-memory or server less runtime engines; and a full range of structured and unstructured storage options. This allows customers to choose from a variety of methods based on their specific needs. Key components of the data fabric that are essential for industrial data processing and management include event hub, analytics services, and data services:

**Event hub** provides data ingestion and a messaging bus for streaming analytics/workload execution and inter-process communication. Industrial applications are event driven and the event bus provides a key resource for developers building real time applications.

**Analytics services** allow developers to deploy analytics to data in motion to transform, analyze and act on real-time operational data.

**Data services** manages infrastructure such as data pipelines, workload orchestration and job scheduling. It has native support for Spark, Hadoop, and serverless big data processing frameworks. Developers will find this useful when building industrial applications that require real time streaming data analytics at high volumes.

**Data integration builds context**
OT Data typically exists as siloes in disparate systems such as PLC, SCADA, MES, Historian, GIS, FADEC etc. Predix Platform includes data connectors to connect to these sources, with the ability to build new connectors. Production data can be extracted and the analyzed data correlated with other IT data (EAM, ERP) and external systems (such as weather or location) to identify data patterns and critical operational anomalies. Adding this context can also support predictive maintenance, impact the supply chain process and drive on-demand procurement of a failed part.
Analytics and machine learning

Today’s industries must not only use data to make stepwise improvements in efficiency, but also to support intelligent decision making based on predictive analytics. Not only can analytics help operators make real-time decisions about critical assets, advanced analytics and machine learning can lead to entirely novel opportunities like autonomous process execution for fleets of assets or plant floor robotics.

Predix Platform supports a comprehensive approach to uncovering the relationships in industrial data by providing a rich, industrial-grade analytics library and framework to create machine learning analytics. When these analytics are applied to data at the edge for example, operational analytics can ensure the efficient operation of assets by detecting and acting upon anomalies in near real time. Those analytics can be improved over time based on historical analysis in the cloud to direct prescriptive controls and signal predictive maintenance alerts.

With Predix Platform, you can:
- Choose from pre-built Predix Platform industrial analytics
- Build, test, and deploy machine learning models
- Leverage in-house expertise and open source algorithms and tools
- Deploy self-learning analytics at the edge or in the cloud

Predix Platform analytics in action: Exelon wind forecasting solution valued at $2M per year

As a leading utility, Exelon and its various power generation subsidiaries generate over 32 gigawatts (GW) of power annually. Managing and utilizing the vast amount of data generated by their nuclear, fossil fuels, wind, hydro, and solar power assets has been a challenge. Exelon’s long-term vision is to centralize and standardize on Predix Platform to provide a single source of truth for data across their enterprise, equip their digital workers, and use advanced analytics and data science to achieve operational excellence.

Exelon and GE took a co-innovation approach to create an analytic solution that could help them better forecast excess wind power capacity, referred to as ramp events, in time to sell the power that is generated. Historically, Exelon’s wind forecasts were not responsive enough to predict wind ramp events. When wind farms had more capacity, they couldn’t dispatch the additional power in the Midwest Independent System Operator (MISO) market because they could not anticipate quickly enough that the power was going to be available. Together, Exelon and GE’s data science team used Predix Platform’s high-control microservices environment by using streaming/batch ingestion, Predix Platform weather and time series service, and analytics to create a new physical and statistical wind power forecast model.

The wind forecasting application built on Predix Platform leveraged horizontally scalable microservices architecture making it scalable to support a wider rollout. In the initial rollout (four wind farms), the application was able to consume data, run analytics in the cloud, and write back results to the edge in just 18 seconds. The analytic model successfully reduced under forecasting and enabled Exelon to sell power generated by short term ramp events. This reduction delivers a 1-3% annual energy production (AEP) gain, equivalent to 70 MW of new capacity valued at about $2 million per year/site fleet wide.

See the full Exelon case study
Mobility and the digital worker

The rise of mobile devices and digital technologies are empowering employees to power a new breed of opportunities. This ‘digital worker’ will be more informed and connected to data than ever before—improving field productivity, reducing costs, and increasing customer satisfaction.

The challenge is how to leverage the power of existing applications built over decades for mobile devices. Many organizations will create new mobile apps that will tap into the data streaming from the asset itself. Doing this will give operators new insights and visibility into the state and performance of the equipment directly from their mobile device. Coupled with predictive analytics, local operators and field personnel are armed with more knowledge to help minimize unplanned downtime and risk. Customer conversations change—becoming less about break-fix and more about future opportunities acting as a trusted advisor that deepens the relationship.

With any application strategy adoption is key. Research demonstrates that the user experience will make or break that strategy. However, that is easier said than done. Employees may be using a variety of device types and vendors located in harsh and remote environments. These new industrial mobile applications may suffer from connection limitations based on the location. However, the user experience needs to continue to be seamless and consistent, irrespective of the connectivity challenges or the devices used.

Predix simplifies building of always-on, mobile industrial applications across many device types.

Predix Platform provides a software developer kit (SDK) and a rich set of cross-platform responsive components that provide a consistent look and feel, and work across multiple mobile devices, laptops, desktops, and browsers. Developers can build mobile apps rapidly by using a common approach for both front-end devices and back-end services that connect with other Predix Platform services—such as Predix Machine—as well as with other enterprise systems. This allows developers to synchronize data between mobile devices and enterprise data domains.

Predix Platform offers a flexible and layered component system, with extensible services that support advanced application behaviors including remote workflow and analytics. Designed to work everywhere, the responsive design includes web components for online scenarios in addition to supporting a native experience using native controls with off-line capabilities for optimal performance.
Predix Platform mobile applications also support a web view, giving the developer the ability to create truly cross-platform applications that will work on a small phone or a large-screen web browser.

Specifically for Apple iOS devices, a Predix SDK for iOS provides developers the ability to build native apps that take full advantage of Predix Platform industrial analytics and the power and ease of use of iOS. Predix SDK for iOS offers rich APIs, user interface elements, and Apple’s programming language, Swift. Developers can easily connect to back-end services, access data offline, leverage the latest iOS technology, and incorporate best design practices. Learn more at https://www.ge.com/digital/blog/predix-mobile-apps-go-native-exclusively-ios

Geospatial intelligence for enhanced insights

Every ‘thing’ has a location. Some of those ‘things’ move around —your online order will weave its way to you on trucks. Some ‘things’ stay in place—like a 500MW gas turbine. In both cases, location is an critical attribute. This is especially important when the data from individual ‘things’ is consolidated with the entire fleet of ‘things’. And when combined with other data points to help deal with local weather conditions or to guide optimization strategies across the business, the power of location is obvious.

Geospatial intelligence allows companies to have a deeper understanding of the context behind the ‘things (or assets in the industrial world) performance. Areas such as field service, transportation logistics, supply chain inventory management, and risk management can all harness location to solve business problems by delivering location-based services.

Predix Platform location and mapping services provide precise location-based information, unlocking deeper insights from any data set and any asset that has a location. Based on an address or a latitude and longitude data pair, everything from the local time to extensive location demographics can be discovered. By combining geospatial with Predix Platform asset and analytics services, businesses can gain a deeper understanding of the context behind asset performance by locating the asset, which can lead to a reduction in downtime, a more accurate estimation of resolution time, and the ability to assess impact based on weather conditions.

Additional services:

- Use enhanced location data for more than 120 countries
- Add lifestyle and demographic insights to your local search
- Integrate administrative call-routing information into 911 processes and workflows
- Incorporate local tax rates into your billing, commerce, payments and payroll applications, processes, or workflows
Build and run applications: developing smarter to innovate faster

Application productivity and control are key for developer teams to deliver industrial outcomes on time and on budget.

Predix Platform provides two environments for application development and runtime, enabling traditional full-stack developers, as well as OT “citizen developers”, to create innovative applications that have the potential to revolutionize global industrial infrastructure.

High productivity development
Predix Studio is a low-code, high productivity, application development environment designed to simplify the complexities of application development such as data integration or managing an application’s full lifecycle. Predix Studio gives customers the ability to rapidly design, iterate, and deliver powerful IIoT applications that address their digital industrial use cases with little coding required. Predix Studio relies on both a visual application builder and a 4GL for users to develop applications. It accelerates the IIoT application development process by automating and abstracting complex tasks common to all applications like data integration, data modeling, and services orchestration.

Automate the plumbing: solving the data integration challenge for IIoT
In order to develop smarter applications, there is one thing that application developers must pay close attention to: the quality of their data and associated data models. Predix Studio solves the data integration challenge through its AI-driven data management workbench to ingest, model, and map data. By applying machine learning algorithms to raw data from disparate sources, the underlying AI engine is able to find unique attributes and connections between the data.

Simplify IIoT development through reusable services
Predix Studio relies on reusable mini-services called plugins to get started building an application. Despite the unique qualities of every industrial environment,
there exists a common set of requirements for any industrial organization seeking digital transformation. These common set of requirements were used to create the initial set of plugins available in Predix Studio for application development. This catalog of plugins allow you to quickly configure it to your data and test, resulting in a more iterative application development process. This enables customers to rapidly install working examples of workbenches, data models, and analytics libraries with little coding required.

Predix Studio allows you to:
- Start small and grow at your own pace
- Quickly and easily develop new applications without coding complexity
- Leverage a catalog of pre-built reusable plugins to accelerate application development
- Easily deploy apps from Predix Studio to Predix Platform runtime environment with a fully integrated continuous integration/continuous delivery (CI/CD) workflow.

**High control development**

Predix Platform offers a full-stack, high-control development experience. Application developers can use a growing catalog of pre-built GE and third party industrial microservices to build, test, and deploy industrial applications. Developers can integrate their own DevOps tools to provide a continuous development workflow that helps shorten the development time.

Developing industrial applications is no easy task as many organizations have great difficulty even connecting to assets and analyzing the data. The full stack development environment improves productivity across the entire development lifecycle by providing all the tools and resources necessary to get started with building an industrial application. Developers have their choice of connectivity, databases, ingestion methods, analytic services, storage, and deployment models. Predix Platform offers industrial services that provide the core capabilities required by Industrial Internet applications (see full list in Predix Cloud section), including:
- **Asset services** to create, import, and organize asset models and their associated attributes
- **Data services** to ingest, clean, merge, and ultimately store data in the storage technology that best suits the use case
- **Analytic services** to create, catalog, and orchestrate analytics to create insights about your industrial assets within your application
- **Application Security Services** meet end-to-end security requirements for Predix applications including authentication, authorization, user management, tenant management, audit and credential vaulting. GE is also actively working within the blockchain community to evolve implementations for industrial use cases such as multiple stakeholders interacting with an asset.

As the destination for developers, Predix.io offers SDKs, tutorials, reference apps, training, certification, forums, and a community code exchange that can help developers accelerate their development experience.
Industrial-grade cyber security: building end-to-end trust

For digital transformation to take hold, connecting critical OT infrastructure to existing internal networks and systems is a necessity. From predictive maintenance and process reengineering to efficiency and productivity improvements, forward thinking business leaders are looking to operational data to help identify new opportunities for growth and profitability. Digital industrial companies therefore demand a high level of security and data governance. From the moment data leaves the asset to the moment it is used in a cloud application, ensuring its availability, validity, and integrity is of primary concern.

### Challenges to IIoT Adoption

- What risk may be introduced to existing systems?
- Implications to compliance, regulatory and privacy posture?
- How can sensitive data be protected with multi-system integration?
- How is data separated from other tenants?

![Graph showing challenges to IIoT Adoption]

*Sources: Morgan Stanley-Automation World Industrial Automation Survey, AlphaWise*

Predix Platform is secure by design, meeting the demanding risk management requirements of industrial organizations. Built with defense-in-depth across every layer, Predix Security addresses the security of the platform itself, the security of the applications it powers, the security of the software development process, and the security of data that flows through the platform. That’s why security is embedded at every layer within Predix Platform.

**Building security into the design of the platform**
- Supporting more than 60 international security standards (see appendix A)
- Designed with a defense-in-depth approach
- Protecting data through tenant segregation and restricted access

**Extending the security into the application development process**
- Application security is an absolute requirement
• Secure development guidelines, tools, and services help build secure applications
• Applications undergo stringent security testing before release
• Lifecycle view protects data flowing across the platform

Continuously monitored for availability, safety, and compliance
• Continuously monitored for anomalies and suspicious events
• Robust threat intelligence to identify imminent threats
• Regular penetration testing of Predix defenses
• Rapid incident response to security events

Multi-layered protection
Predix Platform is based on a gated community model open to tenants that belong to the industrial ecosystem—reducing the risk of bad actors entering the community. Support for various data governance, federation, and privacy needs are included, as well as stringent security requirements such as perimeter security, data security, access control, and data visibility.

• At the edge, Predix Machine provides security, authentication, attestation, and governance services for endpoint devices
• To secure networks, Predix Platform leverages firewalls to restrict network access and uses dedicated intrusion protection technologies to monitor and detect network intrusion
• Predix Cloud offers application security services, such as the user account and authentication (UAA) service, for applications to authenticate users
• Predix Platform provides capabilities such as two-party encryption, support for end-to-end chain of custody reporting for code, and data
Secure platform and apps

GE’s secure development lifecycle (SDLC) framework includes tools, security-related guidelines, and processes that help to secure Predix Platform applications and services during the development process. This empowers developers to: apply the appropriate architecture and design, understand threats and choose the right controls for protection, conduct proper security testing, and remediate vulnerabilities before production deployment.

Governance, compliance, and certification

GE’s holistic approach comprises international standards, security controls from vertical markets, and regional variations. Predix Platform helps to ensure that an organizations fine grained controls (specific to geography or industry) are in place, validated, and audit-ready. This removes the cost for an organization to design and build their own security controls.

See Appendix A for a list of Predix Platform Security Governance and Certification

Business continuity plan

Predix Platform is designed to minimize single points of failure through the use of multiple points of presence (PoPs). Deployed in an active-active model, all data is continuously replicated. Should an incident occur, as each PoP is running Predix Platform instances simultaneously, operations are immediately transferred to another PoP for business continuity.

Data retention and deletion

To ensure data privacy, Predix Platform employs a data retention and deletion policy. This policy outlines the responsibilities of all parties with regard to managing the lifecycle of sensitive data throughout the contract engagement. Tenants retain ownership of their data, with existing data retention and deletion policies also adhered to.

Continuous monitoring and incident response

Predix Platform is continuously monitored by security analysts for anomalies and suspicious events that may require incident response. GE’s incident response program, including on-going training, table-top exercises, pen testing, and vulnerability management, is enhanced by its threat intelligence program. Predix Platform incident responders handle end-to-end coordination with stakeholders for a swift, deterministic incident response from incident notification, investigation, forensics, and close-out.
**Application Spotlight: Predix Asset Performance Management**

Predix Asset Performance Management (Predix APM) is a suite of software and service solutions designed to optimize the performance of your assets. Comprised of Predix Platform-powered SaaS (Software-as-a-Service) and on-premises apps, Predix APM increases asset reliability and availability while optimizing maintenance costs, minimizing risks, and reducing total cost of ownership (TCO). Predix APM connects disparate data sources and uses advanced analytics to turn data into actionable insights while fostering collaboration and knowledge-management across the organization. The suite works across all equipment, all OEMs, and all industries and across the plant and the fleet, and covers the full range of industrial asset needs: APM Health, APM Reliability, APM Integrity, and APM Strategy. Learn more at [www.ge.com/digital/asset-performance-management](http://www.ge.com/digital/asset-performance-management).

“Like GE, Pitney Bowes is in the midst of its own physical and digital transformation. With Predix APM apps running on 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

<table>
<thead>
<tr>
<th>VISUALIZE</th>
<th>OPTIMIZE</th>
<th>INNOVATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leveraging the power of the Industrial Internet of Things, APM gives you a single, secure way to gather data from a wide variety of assets—with or without sensors—as well as other software systems, creating a comprehensive and validated data repository. APM applications provide a unified, complete, and accurate view of the health of your equipment—at the asset, plant, and enterprise levels—anytime and anywhere.</td>
<td>APM applications monitor your assets and alert you to potential problems and failures. Using advanced analytics to leverage vast amounts of equipment data, APM predicts equipment problems before they happen so you can focus resources when and where they are needed. And when issues do arise, APM provides comprehensive case and knowledge management and root cause analysis to ensure that your best practices are captured and available for future use.</td>
<td>The goal of APM is to identify maintenance strategies that balance risk, performance and costs, allowing you to replace scheduled maintenance with just-in time, predictive maintenance. APM takes asset optimization to an entirely innovation level, providing you the quantitative foundation to implement a comprehensive, financially optimized set of asset management strategies to give your business a unique competitive edge.</td>
</tr>
</tbody>
</table>
Growing the ecosystem together

With Predix Platform, GE is transforming the industry. However, the vision is bigger than just one company. Through partnerships with other technology companies, ISVs, academia, consultants, and systems integrators, GE is sharing its expertise and know-how by co-innovating to drive important advances in functionality—harnessing the potential of the Industrial Internet to deliver powerful customer outcomes. The result is a growing Predix Platform ecosystem. Learn more at www.ge.com/digital/partners/meet-our-ecosystem

GE is also a founding member of the Industrial Internet Consortium (IIC), an open membership, not-for-profit group of public and private institutions that focuses on developing use cases and test beds; sharing best practices, reference architectures, and case studies; and influencing global standards development to ensure interoperability.

Growing the Predix Platform marketplace with GE and third party apps

Why choose GE

GE saw a tremendous opportunity to transform the company to drive revenue and services growth, and reduce cost. To do that, it had to do things differently. However, the software and tools required didn’t exist in the market. So, GE built Predix Platform, which it now actively deploys in its own business, IT, and manufacturing operations.

Rather than taking on the entire burden, other organizations can now use Predix Platform to build on its sophisticated infrastructure, and draw from its capabilities and the lessons learned from its industrial experts.

• GE’s billion+ dollar investment in its own digital transformation resulted in Predix Platform
• Decades of experience in industries from power generation to manufacturing to healthcare worldwide has enabled GE to create a platform that meets the unique needs of industry
• GE secures and monitors 50 million data elements of its customers’ industrial assets every day, all in an effort to prevent unplanned downtime for its customers
• GE actively nurtures a 40,000-strong developer community and 1,000-strong alliances ecosystem
so that companies can build and leverage new innovations at speed

- Only GE can enable industrial data science by leveraging its physics and engineering-based models to build machine learning algorithms and offer data science services to help generate insights from data

Learn more

About Predix
predix.com

To start developing on Predix
predix.io

Learn more about GE Digital’s services and products at http://www.ge.com/digital/predix
Appendix A: Predix Platform Security Governance and Certification

Predix Platform has adopted the ISO 27001/27002-based Information Security Management System and the Cloud Security Alliance-based Common Controls Matrix (CSA-CCM) for building its security governance and controls framework. Through these processes, Predix enables support for more than 60 regulatory and compliance frameworks, including the following:

**CSA/CCM 3.01:** The Cloud Security Alliance Cloud Controls Matrix (CCM) is specifically designed to provide fundamental security principles to guide cloud vendors (and to assist prospective cloud customers) in assessing the overall security risk of a cloud provider. The CCM provides a control framework for understanding security concepts and principles that are aligned with the Cloud Security Alliance guidance in 16 domains. CCM also provides a customized relationship to other industry-accepted security standards, regulations, and controls frameworks such as: ISO 27001/27002, ISACA COBIT, PCI, NIST, PCI, and NERC CIP.

**ISO 27001/27002:** Developed by the International Service Organization for Standards (ISO), these standards specify the requirements for establishing, implementing, maintaining, and continually improving information security within the organization. Once certification is attained, users are comforted knowing that security standards are being followed, thereby reducing time and resources needed to address customer-mandated audits and reviews.

**SOC 2 Type 1:** Developed by The American Institute of Certified Public Accountants (AICPA), a Service Organization Controls (SOC) report provides insight on internal controls and risks to users and companies regarding services provided by a third-party service organization (e.g., GE Digital–Predix PaaS). SOC Type 1 reports generate a point-in-time assessment reporting on the fairness of management’s description of the processes as well as advising on the design of the controls.

**SOC 2 Type 2:** Developed by AICPA, a SOC report provides insight on internal controls and risks to users/companies on services provided by a third party service organization (e.g., GE Digital–Predix PaaS). SOC Type 2 reports on fairness of management’s description on the processes and design of the controls (tests of effectiveness of controls), throughout a specified period.

**HIPAA (protects):** The Health Insurance Portability and Accountability Act (HIPAA) protects the privacy of individually identifiable health information. HIPAA compliance provides greater confidence to customers that stored and managed patient health information will be protected.

**Export Controls/ITAR:** The U.S government regulates the transfer of information, commodities, technology, and software considered to be strategically important to the U.S., in the interest of national security, economic, and/or foreign policy concerns. Non-compliance with export controls can result in penalties, including the loss of government contracts and ability to export goods.

Learn more at
https://www.predix.io/resources/security