



# Predix Private Cloud

The highly available, secure, and hyper-convergent on-premises Predix Platform deployment.

## Key Benefits:

- Adhere to regulatory restrictions, guarantee data sovereignty
- Connect and manage edge devices and edge data
- Manage, run, build, and extend IIoT applications
- Unlock value from industrial asset data
- Integrate enterprise-wide data
- Scale hardware and software footprint to meet future business growth



Predix Private Cloud (PPC) is secure, scalable, and hyper converged on-premises Predix Platform deployment at a customer's data center or site.

PPC provides you the ability to monitor, manage, and optimize industrial assets and operations on-premises.

- Enables secure asset connectivity, device management, data management, and analytics
- Allows organizations to build, extend, run, and manage applications

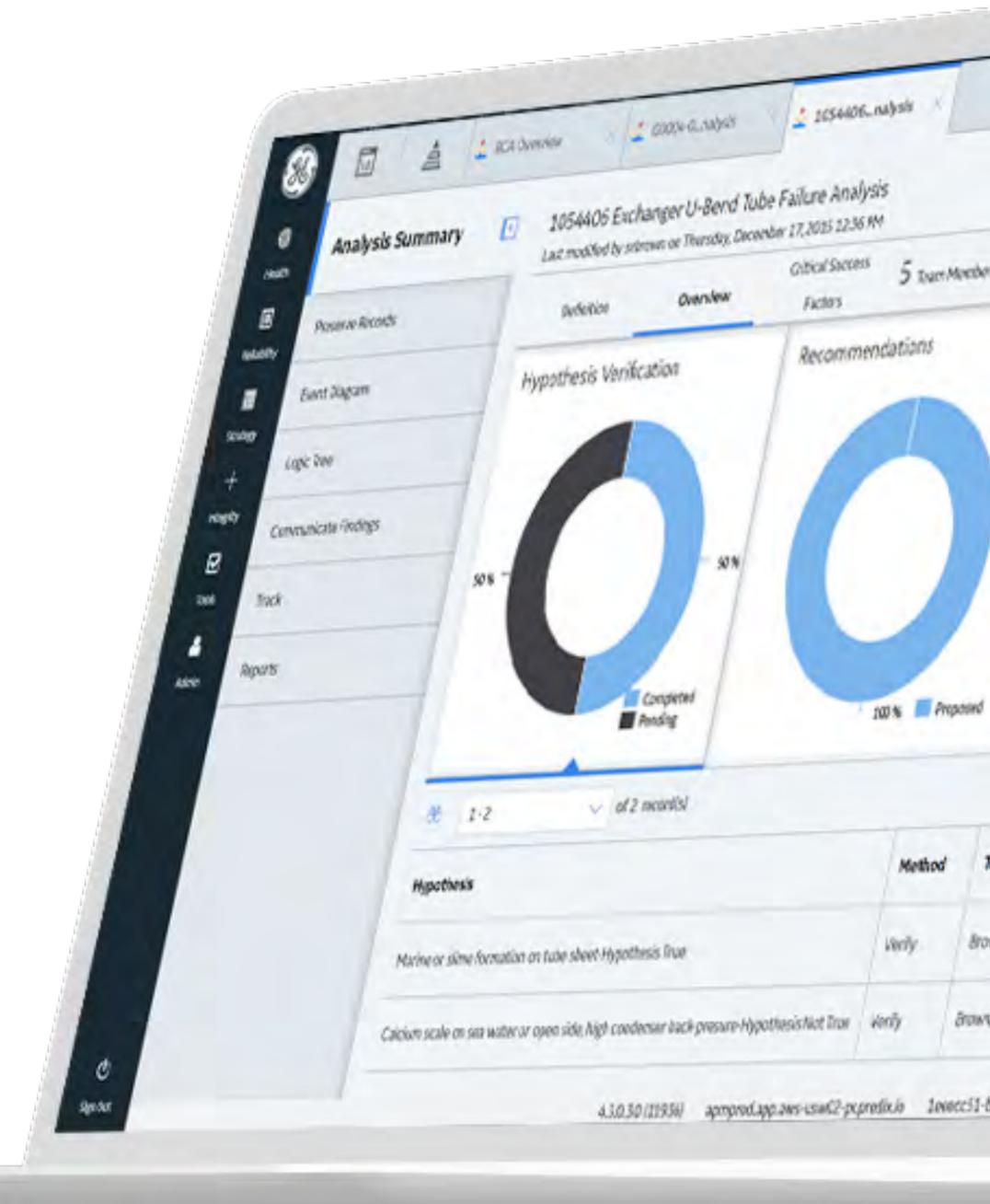
## Why on-premises for IIoT customers?

By 2020, on-premises Internet of Things (IoT) platforms, coupled with edge computing, will account for up to 60% of industrial IoT (IIoT) analytics, up from less than 10% today<sup>1</sup>.

While cloud services offer industrial enterprises an opportunity to increase the speed and reduce the costs of innovation, industrial companies have a specific need to:

- Manage edge and disconnected environments
- Meet privacy, security, data sovereignty, and data isolation requirements based on their industry, region, or country

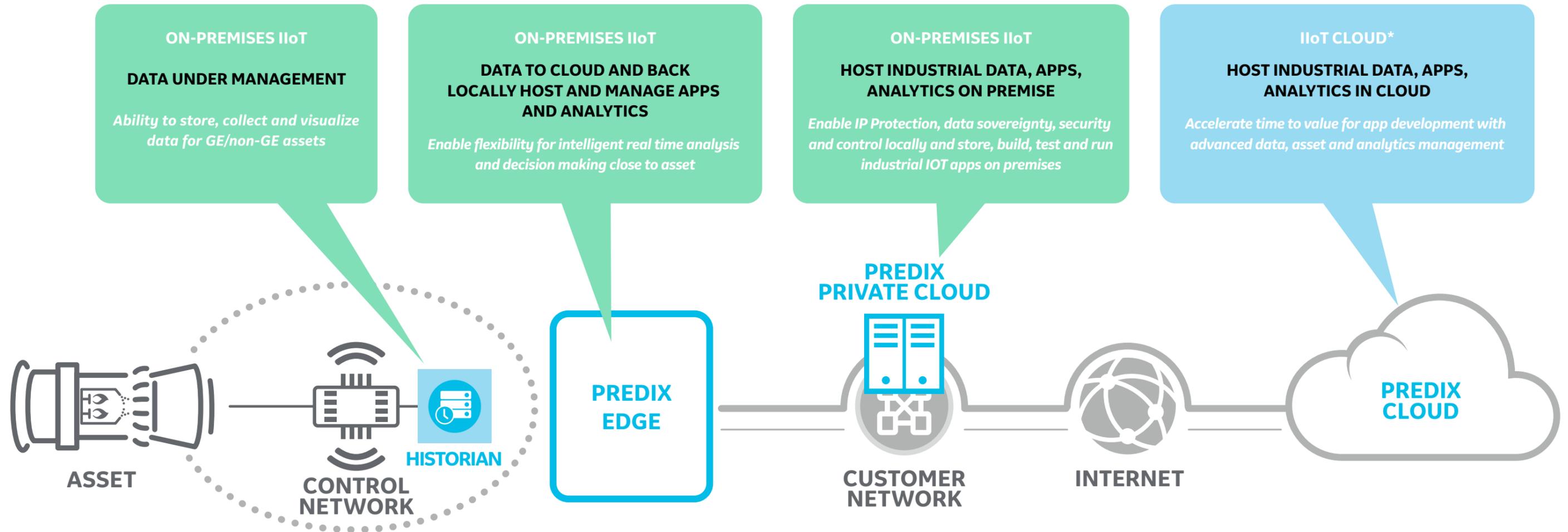
Predix Platform provides a flexible offering to meet varying customer needs in their IIoT continuum.



<sup>1</sup> GARTNER, 2018 Magic Quadrant for IIoT Platforms

# Predix Platform offers choices to meet customer demands

Ability to connect, ingest and store, analyze, and act at every level



**OUTCOME**

- Advanced detection
- Fast/accurate response

**OUTCOME**

- Asset level optimization
- Core control/protection/safety

**OUTCOME**

- Plant level optimization
- Outcome optimizing control

**OUTCOME**

- Run local apps and analytics to enable plant level optimization

**OUTCOME**

- Fleet optimization
- Multi-plant/enterprise/trader analytics

\* choice of deployment location with comparable functionality



Predix Platform is asset-centric and provides a production-ready distributed application platform. Predix Platform provides a deployment model that spans cloud, on-premises, and the edge. This allows organizations to connect to assets, ingest data, perform analysis, and gather intelligence where it's needed. Organizations are empowered to deliver the best industrial outcomes by leveraging the flexibility across the continuum.

Predix Private Cloud brings the agility and fast-paced innovation of cloud computing to on-premises environments. Predix Private Cloud is meant to support your evolving business needs. Organizations can now build modern applications across the on-premises and cloud environments, balancing the right amount of flexibility and control. With access to a consistent set of Predix Platform services at your data center securely, and DevOps processes and tools on Predix Private Cloud, customers, partners, and developers can build applications and then collaborate with operations to deploy to the location that best meets the business, technical, and regulatory requirements.

## The value of Predix Private Cloud for industrial applications

Predix Private Cloud (PPC) is GE's on-premises Predix Platform offering when public cloud is not an option for you to monitor and manage your industrial assets. PPC is built to provide the flexibility and scalability of public cloud in your secure, private environment. PPC is a comprehensive, secure, and transformative digital industrial solution that provides asset connectivity, edge technologies, analytics, machine learning, and big data processing for your industrial applications. PPC

brings industrial data and empowers organizations to unlock new insights across their industrial operations for productivity and efficiency.

Predix Private Cloud is designed for industries and countries that cannot access public cloud due to security requirements and government compliance regulations. Besides providing out-of-the-box IIoT implementation environment that's available on-premises with minimal installation and configuration time, Predix Private Cloud enables following business outcomes:

### Adhere to regulatory restrictions, prevent intellectual property theft through inbuilt "all-in-depth" data, platform, and app security controls

PPC offers a self-contained, secure environment for your assets and operational data. When you are dealing with sensitive and critical data in your industry like defense, healthcare, or oil and gas, PPC ensures your data stays within your data center, and regional or country boundaries for processing. PPC provides you the highest level of security for your intellectual property and protects your data by utilizing sensitive data protection controls.

### Manage, run, build, and extend applications for asset performance optimization

PPC allows hosting and running pre-built asset performance management applications to monitor the performance, health, and reliability of industrial assets. Users can build application extensions for asset monitoring operations and analytical needs that are not standard utilizing native services of the platform. Custom applications can also be built utilizing the availability of the native services on-premises.

### Scale to meet business needs with high availability and performance

PPC empowers you with complete control of your private cloud environment. You can define the development, extension, and deployment of your applications. You can also define the scale of your hardware and software based on your business needs by starting with a small footprint and scaling up as needs increase. High availability and performance levels remain consistent as PPC scales up.

The primary use cases for Predix Private Cloud include:

- Asset monitoring or optimization: Provides real-time view of asset health and condition status, delivers early warning of potential failures, and highlights elevated risk areas.
- Remote monitoring: Monitor faults, and effectively predict potential failures proactively.
- Process and operational efficiency:
  - Manage maintenance and inventory costs, ensuring availability and reliability, and promoting a proactive approach to maintenance practices.
  - Lower environmental, health, and safety (EH&S) incident probability—reducing reactive maintenance and increasing availability.
- Workforce productivity enhancements

The ability to build, run, and deploy custom analytics and applications allows customers to deliver any industrial outcome that can't be delivered out-of-the-box from the solutions that are available on Predix Private Cloud, like Predix Asset Performance Management.



## Core tenets of Predix Private Cloud

PPC is an on-premises cloud environment that's intended to offer the Predix public cloud capabilities hosted in a private data center. PPC as a solution includes hardware and software components:

- **Hardware:** GE Digital certified third-party bare metal servers, racks, and other hardware required to set up the hardware infrastructure.
- **Software:** The software bundle includes multiple Predix and secure third-party services and applications. GE Digital sources combines and applies security measures on these services and application components to create the software running on PPC.

PPC is a hyper-converged platform that enables you to monitor, manage, and optimize industrial assets and operations. PPC provides you the following three options to solve data integration and asset-centric challenges for workloads ranging from several hundreds of gigabytes to petabytes of data:

- Deploy Predix Asset Performance Management (Predix APM) and the Predix application portfolio. You can extend the out-of-the-box applications to suite your own needs.
- Use the available Predix services in PPC to develop, deploy, and operate your own industrial applications.
- Deploy a combination of the two, where APM applications are supplemented with custom-built applications that you have developed.

Predix Private Cloud includes the following features:

**Device Management:** Predix Edge Manager provides a single point of entry for deploying and monitoring fleets of devices remotely. Predix Edge Manager administers applications and configuration files at both the device and fleet level. It supports the management of multi-container edge apps, the Predix Edge secure embedded OS and VMs. Predix Edge Manager enables the lifecycle management of 10,000+ edge devices and has been tested with hundreds of thousands of connected devices. The largest fleet currently administered by Predix Edge Manager contains approximately 10,000 devices.

**Data Integration:** Predix Private Cloud enables organizations to integrate their IT data through data connectors like Enterprise Connect and App Connect with OT data through Predix Edge OS.

**Data management:** Designed to support scalable, extensible industrial use-cases. Data pipeline includes data ingestion, filtering, and tag mapping across multiple data types (e.g. time series, images, SQL, etc.), and support for stateful and stateless services.

**Analytics:** Predix Private Cloud provides capabilities to enable big data distributed analytics with some key capabilities to orchestrate and aggregate various analytics, as well as seamlessly integrate with multiple data sources. It also supports streaming, micro-batch data processing, and data at rest. The results are exposed to end customers through the applications integrated with the offering, like Predix APM.

**Application development:** Besides providing access to out-of-the-box GE Digital applications like Predix APM, Predix Private Cloud allows developers to build stateful and containerized (Docker) applications in Predix Container Service (PCS). PCS offers a highly available environment to run stateless as well as stateful workloads. PCS provides a highly available environment for application teams to self-serve scheduling and running of their container workloads. The environment offered to customers will support container defined persistence storage.

**Security:** Defense-in-depth across the stack. Authentication, authorization, user management, end-to-end tenancy, data privacy, and other services help reduce risks associated with applications. Cyber and information security that meets industrial assets and data compliance requirements and standards.

**Scalability:** Ability to scale up and scale out as business needs grow.

**Fail over protection:** All components interconnect and are fully redundant within a rack. Design supports multiple servers across multiple racks for higher level of failover protection.

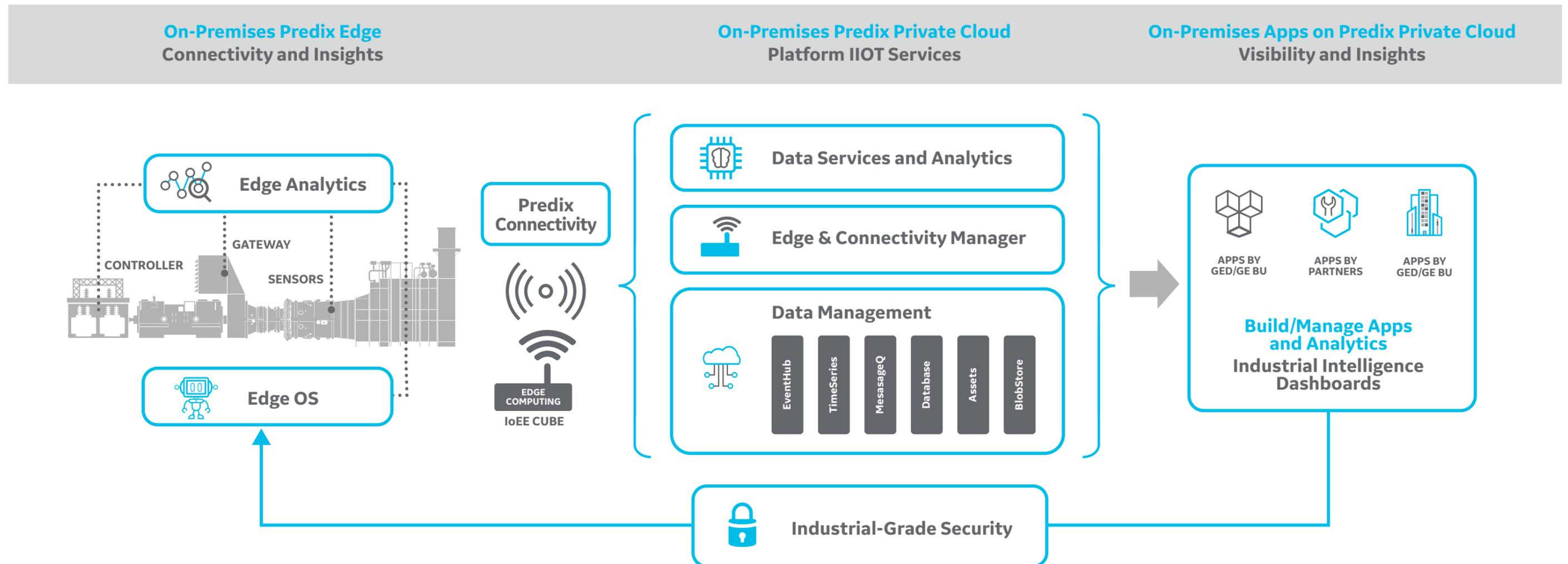
**Performance:** Provides local processing capability that reduces cost and latency and increases data processing efficiency.



Here is a high level view of end to end IIoT implementation with Predix Private Cloud:

# End-to-end on-premises IIoT implementation using Predix Platform

# PREDIX



## Predix Private Cloud: A deeper dive

PPC is designed for industries and countries that cannot access public cloud due to security requirements and compliance regulations. PPC provides the following business outcomes:

- 01 Data sovereignty and data isolation in compliance with local data regulations**
- 02 Prefabricated environment with minimal installation and configuration that allows on-premises update on capabilities**
- 03 Ability to develop, build, and deploy Predix services-based applications on-premises in a secure, self-contained environment**

### Infrastructure

PPC's secure and scalable infrastructure is built on reliable and powerful hardware and software components. These components provide the compute, storage, and networking capabilities for virtualized computing, software defined storage, and networking resources on-demand. The hardware agnostic infrastructure-as-a-service provides the resources and capacity to manage very large amounts of data from industrial operations.

## Platform-as-a-Service

PPC's Platform-as-a-Service provides distributed computing, big-data analytics, asset data management, and machine-to-machine communication. PaaS provides the platform and environment that allows developers to build applications and services in PPC. The PPC platform runs on Cloud Foundry (CF) using the following components:

- **CF Application:** CF uses a self-healing container management system to manage applications.
- **CF Runtime:** CF Runtime is a code-centric platform. It takes the code, written in any language or framework, and runs it on any cloud. It provides easy access to CF application properties and services.

PPC allows deployment of the following services to provide security, data management, analytics, monitoring, and viewing capabilities. You can also use these services to build and deploy your own applications on PPC.

- **Device Management Edge Manager** – Predix Edge OS is a hardware agnostic Predix software stack that helps with developing solutions for retrieving data from industrial equipment and its secure transmission to PPC. Predix Edge OS works with Predix Edge Manager to provide a single-pane-of-glass for remotely and centrally viewing and managing many edge devices to perform software updates and install edge apps and analytics.



- **Data Management Services**
  - **Asset:** The Asset service provides REST APIs to support asset modeling. This enables application developers to create, update, and store asset model data that defines asset properties and relationships between assets and other modeling elements. Asset service also helps data consumers to retrieve asset data.
  - **Time Series:** Time Series service provides the ability to collect data as a sequence of data points in specified time intervals over a period of time. Time Series also provides efficient storage and fast analysis of continuous stream of sensor data.
  - **Blobstore:** Blobstore service provides the ability to securely upload, store, and retrieve large volumes of data, of any binary file types.
  - **Event Hub:** The Event Hub service provides secure option for applications, devices, and services to intercommunicate. Event Hub can ingest streaming data and send it to the cloud for processing.
  - **Analytics Framework:** Analytics Framework service simplifies developing advanced business analyses and deploying them to business operations. This service provides the following features for developing and embedding advanced analyses in industrial operations.
    - **Analytics catalog** for sharing reusable analytics across development teams
- **Orchestration runtime** to configure, execute, validate, and monitor analytics to run as a single unit
- **Scheduler** to schedule the execution of an orchestration or an individual analytic at a time-based interval
- **UI** for web-based access to catalog features and to upload and test your analytics
- **Predix Insights:** Predix Insights provides a technology-agnostic platform to use big data frameworks like Spark to run your analytics.
- **Postgres SQL:** PostgreSQL is a database-as-a-service object-oriented relational database management system to store data securely for retrieval at the request of other software applications.
- **Predix Message Queue:** Predix Message Queue is a message broker software service that provides persistent, highly available, and reliable messaging between applications, components, and devices.
- **Predix Cache:** Predix Cache provides the in-memory data structure store that is used as a database, cache and message broker.
- **Operational Services**
  - **Predix Monitoring:** Allow monitoring of applications and network
  - **Predix Logging:** Provides the ability to collate and view log files
- **Application Services**
  - **App Hub:** App Hub service provides the ability to combine one or more microapps together with a global navigation and a common mechanism for user authentication.
  - **Views:** The View service stores visual templates that define a specific layout. These templates can be shared across different applications to avoid redundant code.
- **Security Services**
  - **UAA (OAuth):** UAA enables developers to securely authenticate application users.
  - **Access Control Services (ACS):** Access Control Services (ACS) offer a simple process to add security for Predix application developers. Using ACS, developers can add granular authorization mechanisms to access web applications and services without having to add complex authorization logic to their code. ACS works in conjunction with the User Account and Authentication (UAA) security service.
  - **Predix Vault:** Predix Vault provides the ability to securely store and access credentials.
  - **Predix Audit:** The Predix Audit provides a standard way to audit and query events. It is built to be secure, scalable and fault tolerant.



## Security

Predix Private Cloud (PPC) is built for customers' private, on-premises cloud. PPC provides customers with an exclusive cloud within their data center for complete security. PPC is built with multiple layers of authentication, access controls, and other security measures to protect industrial assets, asset data, and prevent security threats. PPC is built with high standards of security to protect information and access. Such security is made possible by applying security measures from the cyber security and application security levels.

PPC's security is validated and tested with components such as next-generation firewall, scalable prevention and detection capabilities, vulnerabilities and anomaly detection capabilities, and security information and event management (SIEM).

IloT Private Cloud Security Requirements	PPC
Centralized Access and Authentication	x
Application Security	x
Encryption & Data Security	x
Intrusion Detection System (IDS)	x
Centralized Logging and Monitoring	x
Edge Security	x

- **Centralized access and authentication:** PPC security services integrates with centralized Active Directory (AD) and Lightweight Directory Access Protocol (LDAP) to securely manage and connect users to their systems, applications, files, and networks.
- **Application security:** Scalable web application firewall (WAF) with prevention and detection capabilities provides centralized access to microservices through Free IPA for the highest form of application security.
- **Encryption and data security:** PPC supports latest form of transport layer security (TLS), secure socket layer (SSL) data encryption for securing your assets data.
- **Intrusion Detection System (IDS):** Signature-based IDS includes a combination of OS security and vulnerability scanner to protect PPC host and anomaly detection capabilities for network protection.
- **Centralized logging and monitoring:** Security information and event management provides options to log application, network, and host logs. You can build alert dashboards to customize notification capabilities based on your requirements.
- **Edge security:** PPC enforces two-way mutual authentication and centralized certificate-based security controls using trusted platform management (TPM). Edge devices are built with chips for security. Data transported from the edge device to cloud is encrypted using TLS.

## Applications

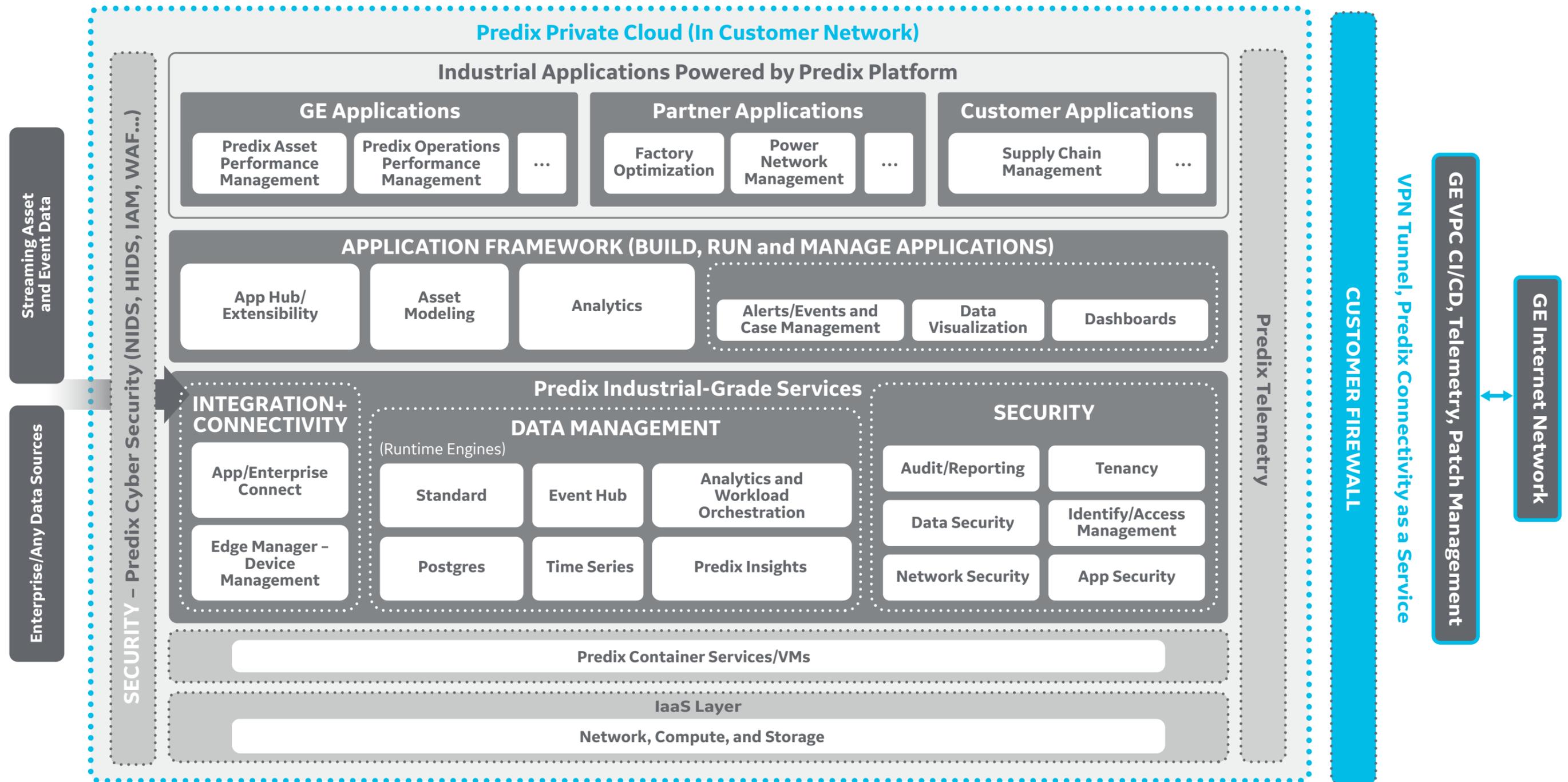
Predix Private Cloud offers out-of-the-box applications and also an ability to build and extend IloT applications to meet the growing business needs.

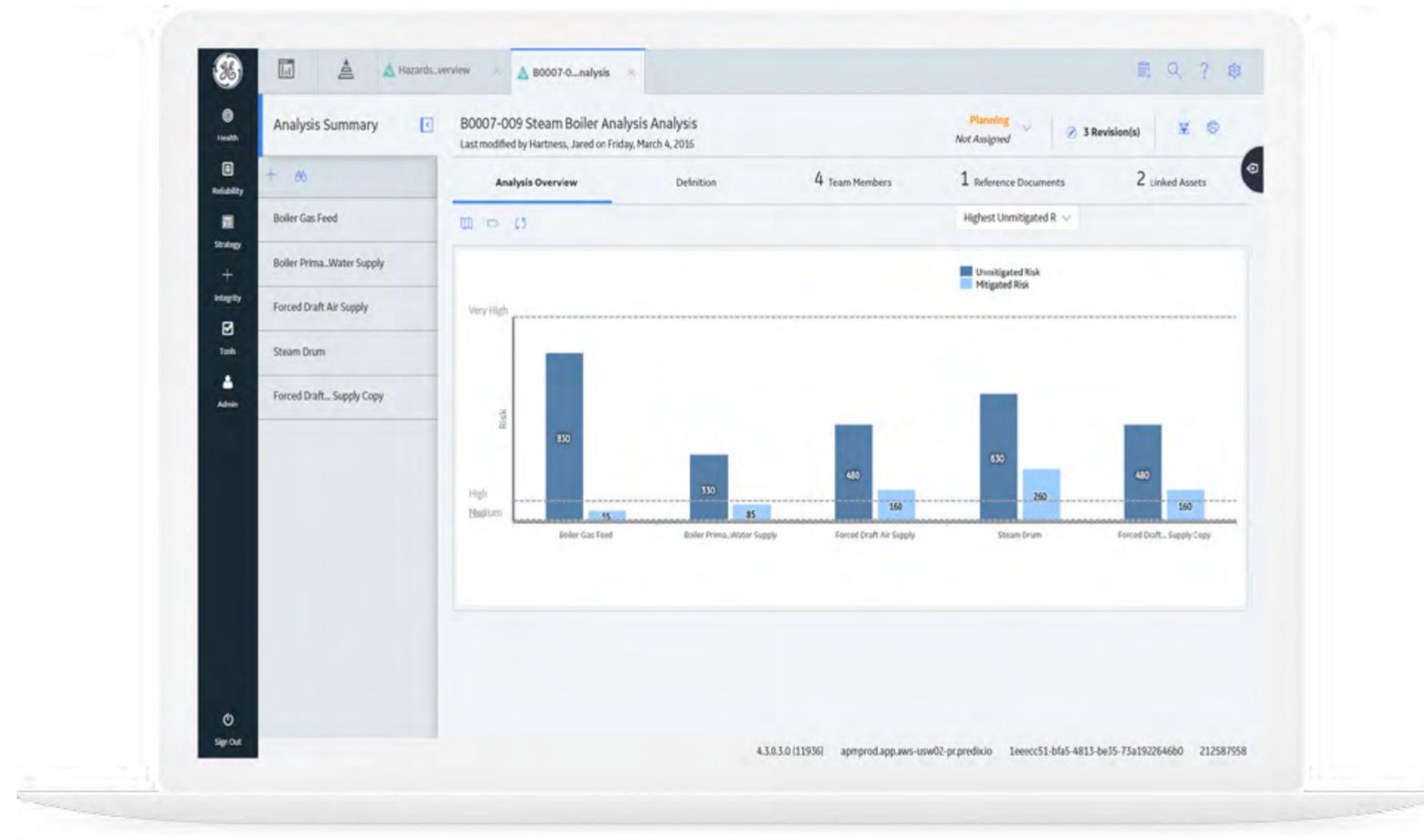
- **Out-of-the-box access to Predix applications with ability to extend:** It is optimized to host Predix APM application suite and other industrial asset management applications from GE businesses. Based on the organization's requirements, you can choose any Predix application for your specific industrial use-cases. You can also use Predix Platform application services to develop and deploy custom applications, reports, and analytics.
- **Build, deploy, and manage custom applications:** PPC provides a flexible application development experience that you can build and host custom IloT applications by using one of the following options:
  - Build applications, test, and deploy in PPC
  - Build and test application in public cloud and deploy in PPC

Using the Cloud Foundry for PaaS layer and application runtime, Predix Private Cloud provides Predix Platform application services that you can use to build custom applications. These capabilities form a single code base that enables you to port, develop, test, and deploy applications for your IloT use-cases.



# Hyper-convergent, highly available, and secure PPC architecture





## DevOps

DevOps leverages automation tools to drive software deployment and delivery. PPC's microservices-based architecture forms the basis for a continuous integration, deployment, and delivery model using task automation and orchestration. The PPC DevOps environment supports integration with your own CI/CD tools to accelerate software delivery onto Predix Private Cloud. PPC's DevOps support can significantly reduce deployment time for cost efficiency.

## The fastest path to innovation

Application productivity and control are key for industrial customers to deliver industrial outcomes on time and on budget. Predix Platform offers a deployment model that spans cloud, on-premises, and the edge to meet the customer's evolving business needs. Organizations are empowered to deliver the best industrial outcomes by leveraging the flexibility across the continuum with Predix Edge, Predix Private Cloud, and Predix Cloud offerings.

At GE Digital, we are committed to operational excellence, simplicity and ease of application creation, implementation, and adaptability for our customers and partners through our platform. With Predix Platform, we want organizations to have a simplified approach to industrial application development and focus on driving innovation by leveraging the deep domain expertise of GE and its ecosystem of partners.





## 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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