WHITE PAPER

A Software Platform for Operational Technology Innovation

Sponsored by: GE Software

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IDC OPINION

With the expansion of intelligent, connected machines for mission-critical operations, we are witnessing the convergence of information technology (IT) and operational technology (OT). The ability to control operational devices over the Internet brings with it an imperative to apply IT disciplines like security and data governance to the realm of industrial operations. With appropriate safeguards, it is now possible to analyze the data from sensor-enabled machines for business advantage. IDC research shows that product innovation and asset and operations optimization are leading the way as drivers for Big Data and analytics initiatives. Examples range from measuring asset performance to real-time monitoring and adjustment to predictive maintenance. To take advantage of these opportunities, organizations need an IT-compliant software platform for operational technology. Such a platform must provide:

- *Machine centricity:* Machine software and machine-to-machine (M2M) connectivity in operations are the targets for intelligent applications. Given the proliferation and variety of mechanisms (and lack of common standards) for communicating with different types of machines and the traditionally tight coupling of hardware and software, the platform should provide a layer of abstraction that enables applications to be built easily and extended seamlessly in this networked operational environment.
- *Heterogeneous data acquisition, storage, management, integration, and access:* Operational technology applications require access to diverse types of data — structured, semistructured, and unstructured from the back office to machines. 80% of an analytics project typically involves gathering and then preparing the data for analysis. A platform for asset and operations optimization must be scalable to handle large data volumes and support the aggregation and integration of data from a variety of machines with other asset-related business information.
- *Advanced predictive analytics:* The platform must support data scientists and business analysts crunching through massive volumes of machine and other operational data for a variety of use cases. These include discovering early signals that predict machine failure to determine priorities for asset maintenance or anticipating a shift in demand that will impact operations delivery capability. The lessons learned should drive prescriptions for the next best action to take.

- *Intuitive user experience:* Operations professionals need an intuitive, engaging, mobile-centric user interface for real-time monitoring of machines and supporting tasks such as repair and maintenance, guided by analytical models.
- *Secure deployment in the cloud or on-premise:* Operational technology applications must be capable of development and customization in a manner accessible to developers familiar with standard programming interfaces for deployment in a secure environment, either in the cloud or on-premise.

GE's Predix is a software platform for developing and deploying innovative operational technology applications designed to address the challenges and opportunities at the intersection of people, machines, and Big Data and analytics.

IN THIS WHITE PAPER

An operational technology platform is a specialization of what IDC calls the "3rd Platform" built for the new generation of IT applications that incorporate Big Data and analytics, social business technologies, cloud deployment, and mobile-centric user interfaces. A focus will be applications for asset and operations optimization such as predictive maintenance across the range of asset-intensive industries. GE, with the help of its partners, is delivering the Predix platform to address this need.

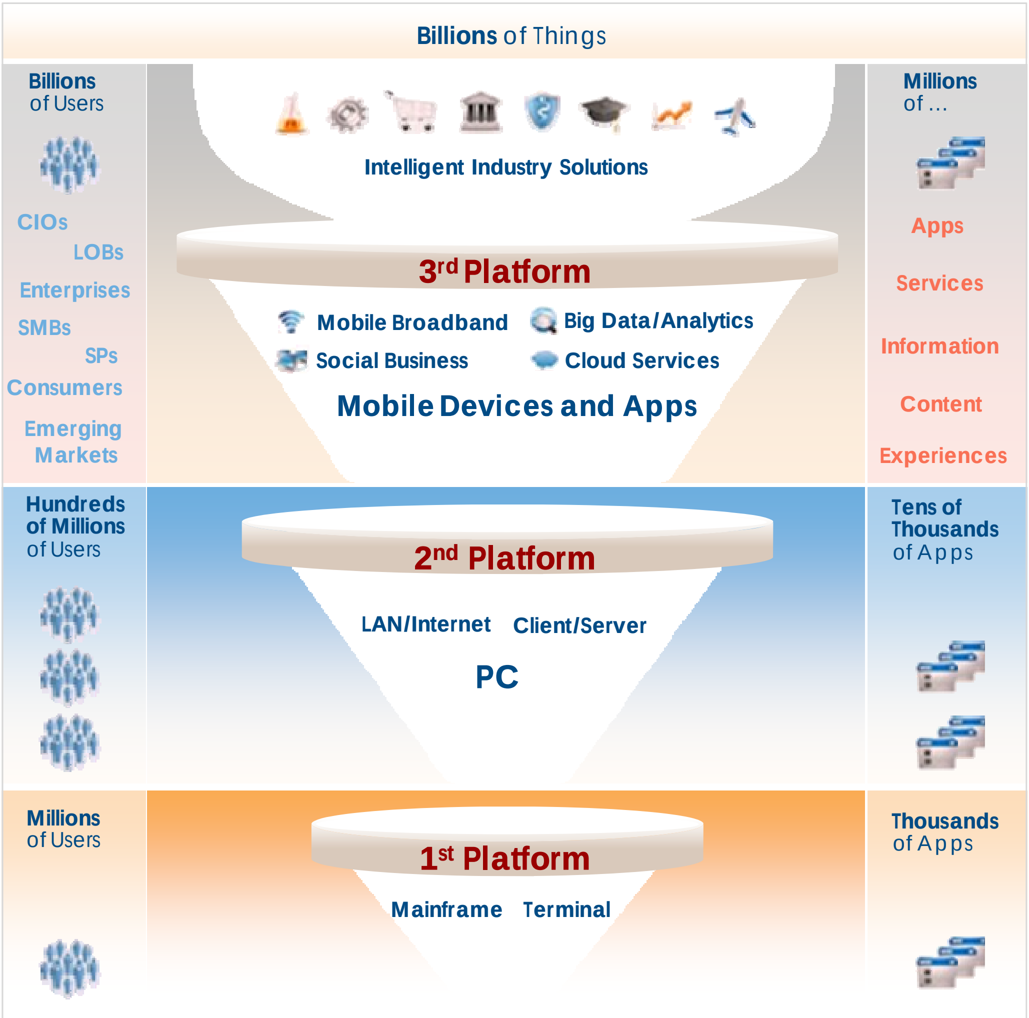
SITUATION OVERVIEW

Figure 1 illustrates the forces coming together to launch a new generation of innovative, intelligent applications: mobile centric, securely deployable, leveraging Big Data and analytics, and processing signals from billions of things (connected over the Internet) for high-value decisions.

IDC believes that 75-80% of these intelligent industry solutions will be data intensive. Sensor data from connected machines is enabling real-time monitoring and problem detection for improved operations. This goes beyond what traditional systems can deliver such as back-office, ERP-related billing, procurement, and enterprise asset management systems — leveraging massive amounts of sensor data via advanced predictive analytics. The ability to build and deploy these applications requires a specialization of the "3rd Platform" for operational technology built to meet the demanding data, processing, and user interface requirements in the context of what has been called the "Internet of things" or the "Industrial Internet."

FIGURE 1

3rd Platform: Enabling Intelligent Industry Solutions



Source: IDC, 2014

Business Context: The Industrial Internet

Business leaders today are realizing the value of Big Data and analytics as a key to improved operations. Confirming this point, a recent IDC survey of business and operations professionals showed that the leading driver of Big Data and analytics projects is "product or service improvement and innovation." This factor was cited by nearly 50% of respondents. The same study reported that over 40% of respondents selected "process and operations optimization and control." In addition, IDC research on analytics applications over nearly 20 years has shown that analytics on operations yields a higher return on investment (ROI) than any other major category or use case – more than customer-facing projects and more than financial analysis.

It's not difficult to understand why operations analytics yields a high ROI. The failure of a machine critical to an operational process can have a major impact on the revenue that can be generated by a firm. For example, assume an oil exploration company extracts $100 million worth of crude oil over the course of a month. A prediction of an exploration machine's likely failure in time to repair it can avert revenue losses in millions of dollars for each day the operation is shut down.

Aside from loss of revenue when operations must be shut down, there is also the cost of maintenance. One extreme example is a blowout preventer in the oil and gas industry. A blowout preventer is a complex machine positioned on the ocean floor that is used to monitor the offshore oil well as a last line of defense before a catastrophic blowout. Planned maintenance requires pulling the machine up to the surface to replace worn out or potentially defective parts — an operation that can cost between $10 million and $16 million. Predictive maintenance software recommends which parts need to be replaced. If this predictive software does its job well, the oil and gas company can avoid an unscheduled resurfacing of the machine to replace a defective part. Accurate, timely predictions can save millions of dollars in maintenance costs.

Example: An Analytical Service for Predictive Maintenance

A mining company has remote operations for mineral extraction that depend on expensive equipment to operate dependably and efficiently. Software based on the analysis of machine data communicates with software running on the machine to direct the positioning of drills and other mineral extraction equipment for maximum impact in the real-time operational context. The company has a maintenance contract whereby the manufacturer can be called in to fix the equipment when it breaks. But getting to the remote site to do the repair could take days and cause a costly disruption to operations until the repair can be scheduled and completed.

To address the line-of-business need for visibility and advance warning of machine failure, the manufacturer introduces a new predictive maintenance service to monitor its equipment for signs of potential failure. When these early warnings have been detected, the manufacturer intervenes with a proactive repair to the machine before it fails, with the correct spare parts delivered in time for onsite repair. The result is continuous operations without disruption.

The mining company is willing to pay more for the new service than a traditional break/fix contract, given the incremental benefit it can realize in protecting mission-critical operations. The mining company is also pleased that it does not have to hire data integration specialists to prepare the data and find data scientists to build the predictive models behind such a service. The new Big Data-based analytical service is a win-win both for the asset-intensive company and for the manufacturer, targeting a high-value decision in mission-critical operations. GE estimates that the savings in repair costs for a mining company can be up to $2 million per year and the operations productivity improvement for well-maintained machines can save up to $8 million per year. Savings can be even higher in other industries.

Analytics for Connected Decisions Across Multiple Operations Roles

Predictive maintenance addresses one key area for operations process improvement. But it's only a beginning. The information gleaned from the real-time operations on the expected lifetime of an asset and the shifts in demand for service can enable operations planners to make better decisions in allocating financial resources to procure, distribute, and provision assets (i.e., for generating power and for providing health or transportation services). Data scientists, in turn, can research new approaches to gain even greater efficiencies for fuel consumption and other costs.

Improving one decision and sharing what is learned can help those in the organization in different roles who are faced with making related decisions. Making these connected decisions (and the decision makers) fact based can improve end-to-end operations process performance.

Let's consider how analytically driven connected decisions and the people responsible for them play out in an aviation scenario:

- **Plan and analyze (*Operations Planners*):** For commercial aviation, planners build and revise flight schedules to meet consumer demand in a way that minimizes costs to the airline. Analytics can help planners continually tune crew schedules, plane maintenance schedules, and routings. Cost levers include reducing the number of overnight stays for crews, lowering the average fleet age to save on maintenance costs, and improving the calculation of "no show" passengers for improved revenue management. Such schedules must be coordinated with financial plans and goals, incorporating data from financial and enterprise management systems as well as the aggregation of data reflecting outcomes of recent operations.
- **Sense and respond (*Real-Time Operators*):** In the real-time environment, when the plane is preparing for takeoff and when in flight, data (weather, traffic) must be monitored by the pilots for their plane in conjunction with air traffic controllers who monitor data on conditions impacting multiple planes within the airspace of their responsibility. Adjustments to the flight plan may be made in flight in pursuit of on-time performance and optimized utilization of fuel resources. Some changes are automated (driven by analytics and rules), while some are human initiated, utilizing intelligence based on operation-specific analytics. In cases of a disruption (signaled by real-time operations monitoring), plans can be rapidly changed to meet the new situation.
- **Model and predict (*Data Explorers*):** Data scientists and business analysts (employed by the airline, an engine manufacturer, and/or an independent firm providing analytic services) are *data explorers,* crunching through massive data sets from machine sensors on planes, seeking to discover early warnings of equipment failure that can cause delays and missed schedules. These models give real-time operations personnel guidance on what factors should be monitored and give planners insights on what priorities to use in developing flight, maintenance, and crew schedules in the future. The collaboration across roles in sharing information and models improves overall efficiency in an end-to-end operational process.

A platform for operational technology must support each role (operations planner, real-time operator, data explorer) with the style of analytics used in each context. What makes this complex is that separate data management platforms have emerged to meet the analytical needs in support of these three roles:

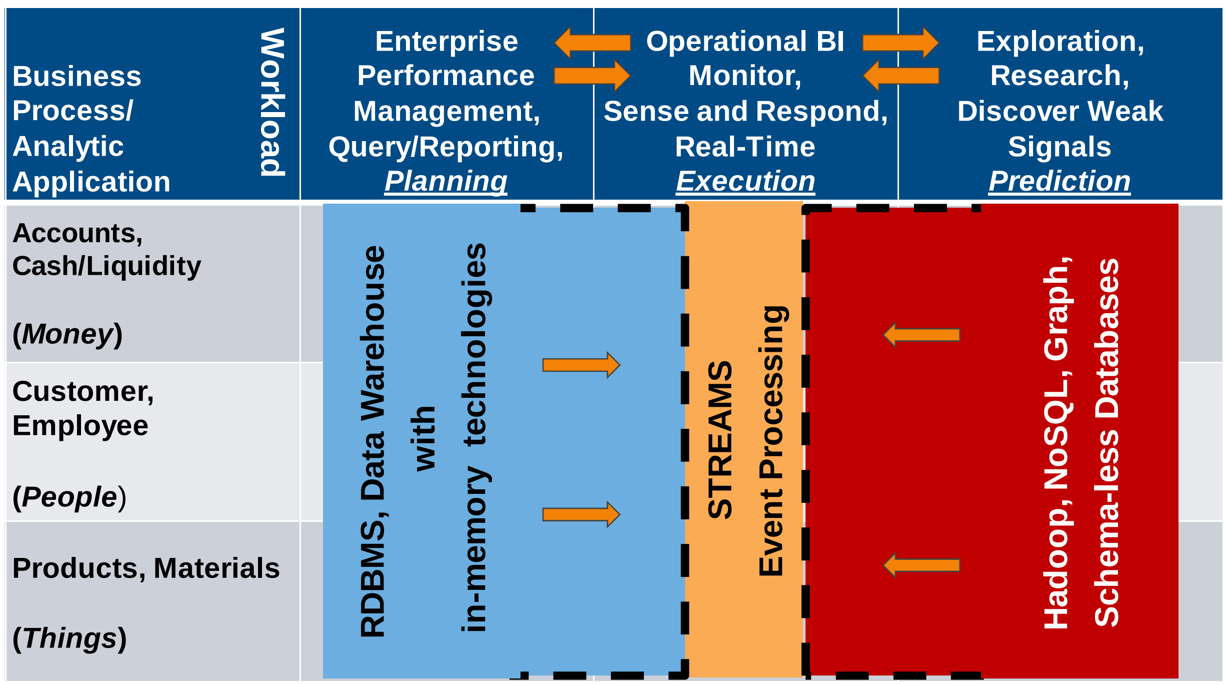
- **Plan and analyze:** *Relational databases* have traditionally supported the work of operations planners. When relational databases are enhanced with *in-memory* technology, planners can flexibly adjust plans and forecasts and are able to take account of the freshest data.
- **Sense and respond:** The management of *streaming data* is necessary to support real-time operators — monitoring machine and operations process events, listening for signals, and enabling corrective actions.
- **Model and predict:** Data coming from the machines can be semistructured or unstructured. New *schema-less* data management technologies (such as Hadoop and NoSQL) are coming into play to provide raw data (before it has been defined) in support of discovery-type analytical work by data scientists.

A platform for operational technology must bring together all of these capabilities in support of operational roles and connected decisions from planning to real-time operations to discovery. It is complex to develop an operational technology application that must access three separate data management platforms (relational, real-time streaming, and schema-less).

IDC believes that the future is platform convergence – bringing together all of these data management capabilities in a unified platform. Figure 2 illustrates this anticipated convergence in support of Big Data and analytics applications (whether about money, people, or things/machines) for planning, real-time operations, and predictive modeling roles.

FIGURE 2

3rd Platform Convergence for Big Data and Analytics



Source: IDC, 2014

Technology Context: 3rd Platform for Asset and Operations Optimization

The 3rd Platform enables new applications for growth and innovation, built on the technology pillars of mobile computing, cloud services, Big Data and analytics, and social networking. Adoption is being driven by business requirements for mobile access by a distributed workforce, enhanced collaboration for innovative social business processes, and predictive analytics to anticipate issues and prioritize decisions for resolution — made available for cloud-agnostic deployment to mitigate implementation complexity and risk.

Operational technology applications require a specialization of the 3rd Platform, taking account of unique ***machine intelligence, data, analytics, user experience,*** and ***secure deployment*** requirements and real-time (or near-real-time) decision making using deterministic machine-to-machine networking.

Machine Intelligence Requirements for Operational Technology

The platform must be specialized to enable the building and running of operations applications that analyze data from and intelligently control networked production machines. Traditionally, intelligent machines were implemented via embedded proprietary software requiring specialized developer skills. Modern operational technology applications should be built using standard application programming interfaces that apply across machines, masking the unique characteristics of each of the diverse machines that participate in the execution of the operations process.

Data Requirements for Operational Technology

Consider the unique data requirements. Connected, sensor-instrumented industrial devices are yielding data of high velocity, volume, and variety (i.e., Big Data) that is challenging to manage and analyze:

- Velocity: Data comes in rapidly from large numbers of intelligent, connected machines.
- Volume: Sensors emitting signals as close as milliseconds apart leave a data trail that can reach petabyte scale.
- Variety: The resulting data that is relevant for understanding and improving operational processes can be structured, semistructured, or unstructured.
- Veracity: The data can be noisy and of uneven quality. Unless the issue is addressed with an enterprise commitment to management and governance, the conclusions derived from the data will be suspect.

These four Vs define what has been termed by the technology industry as *Big Data.* In the Industrial Internet, capturing and managing this machine data is complex, beyond the capability of traditional relational databases.

An operational technology platform must provide a unified approach to manage this machine data and its integration with traditional data sources such as enterprise asset management applications and demand planning systems.

Analytics Requirements for Operational Technology

Consider the requirements to support analytics for diverse organizational roles and the decisions they are responsible for. To meet the business requirements of diverse organizational roles, the platform must support a range of analytical techniques (refer back to Figure 2) – from traditional reporting and planning to real-time monitoring to discovering signals that can improve the accuracy of predictive models.

- **Performance management:** Reporting must show updated information on actual versus forecast results, for measuring and managing operational performance. Planners need a multidimensional view of the results in order to make trade-offs on future schedules or investments in assets.
- **Real-time monitoring and event processing:** Monitoring must provide visibility into events that are captured in the course of real-time operations, analyzing data on the fly and communicating with heterogeneous devices to take action, such as the positioning of a single asset (like a drill or turbine) or the coordination of multiple assets to achieve a result (maximum energy output, minimal fuel consumption).
- **Advanced predictive analytics:** Exploration and discovery seeks to find weak signals of significant events (asset failures, missed schedules, sudden spikes in demand) using an array of analytical techniques applied to asset and operation processes. The massive data sets captured from the machines may require moving the analytical model to the data to minimize the load on the network.

An operational technology platform must provide a range of analytical techniques from reporting what happened to monitoring what is happening now and anticipating what is likely to happen based on current observations.

User Experience Requirements for Operational Technology

Consider initiating a program to transform people within your organization (and external stakeholders) so that they change from gut-based to fact-based decision makers. A key requirement is a human interface that provides an intuitive user experience that engages people, providing visibility to operations, and helps to focus attention on the most impactful factors:

- **Any device:** Consistent, synchronized information should be available and accessible from any device, including all flavors of mobile and with access to any machine relevant for the operations process.
- **Relevant in context:** We are in a state of information overload. A user interface must help users focus on the information that is most relevant to their role and the decisions they are responsible to make, such as signals, which are early indicators of asset failure. In the future, wearable computers using technologies such as smart glass can help support this goal in the real-time environment.
- **Descriptive or prescriptive:** The interface should enable an individual to monitor the performance of a machine (*descriptive*) and advise on the next best action (*prescriptive*) to correct or adjust a machine or machine-intensive process.

An operational technology platform must provide a consistent, intuitive user experience, no matter the operations process or machine asset that is being monitored or adjusted.

Secure Deployment Requirements for Operational Technology

Operational technology applications must be developed, deployed, customized, and extended in a secure environment either in the cloud or on-premise for maximum flexibility. Security at the user access, resource, and data levels should be supported.

An operational technology platform must provide a secure means to deploy applications, either in the cloud or on-premise.

Applying the 3rd Platform for Asset and Operations Optimization

Operational processes vary greatly by vertical, so a more detailed view would show a row for each industry. Yet there are already emerging clear areas of opportunity that are common to operations in multiple verticals. Predictive maintenance applies to physical asset utilization, applicable to any asset-intensive business. Sales and operations planning (which seeks an optimal balance of demand, capacity, and inventory) can be improved by adding predictive demand sensing.

Example scenarios (of Industrial Internet) in several industries — aviation, energy management, healthcare, oil and gas, power and water, and transportation — show that asset-intensive industries will benefit most from the application of the 3rd Platform for asset and operations optimization. Traditionally underserved by corporate IT, operational technologists will look to the 3rd Platform to rapidly build and deploy analytic applications for asset and operations optimization. The 3rd Platform must link business functions responsible for asset maintenance, operations process monitoring and remediation, and optimized asset utilization and planning.

Table 1 shows the way several industries are prioritizing the tasks and applications for operational processes.

TABLE 1

Asset and Operations Optimization by Industry

Industry	Use Case Description	Real-Time Asset Optimization	Real-Time Operational Optimization	Benefits over Traditional Approach
Aviation	Real-time monitoring of airliner condition and status, including the use of predictive analytics to determine proactive maintenance of the transportation asset and fleet	Use of sensor data to monitor aircraft performance in flight to enable both preventive maintenance and rapid deployment of spare parts in anticipation of a repair requirement	Fleet management visibility and real-time monitoring to ensure business performance and proper adherence with operating regulations; the ability to deploy backup or alternative assets for predicted repair delays or anticipate flight crew or asset fatigue with proactive redundancy	Enables more effective anticipation and diagnosis of potential asset fault conditions to minimize downtime and anticipate alternative solutions to reduce business or service disruptions Metrics: On-time departure and arrival; maintenance cost and disruption cost
Energy management	Real-time monitoring and control to optimize performance of energy-consuming equipment	Use of predictive analytics to detect false sensor flow readings initiating variable frequency drive and consumption of excess energy	Use of analytics to initiate lighting, HVAC, and plug load controls based on occupancy density	Enables reduced costs, especially when utilized in conjunction with demand response programs Metrics: HVAC cost per ton, energy cost per square foot
Healthcare	Medical device performance monitoring and tracking in real time linked to predictive analytics to ensure proper maintenance schedules and high availability	Use of sensor data to monitor operating condition of complex, fixed-position assets to enable preventive maintenance as well as the use of geopositioning technologies to track the specific location of "mobile" assets to ensure they are where they are needed	Use of sensor and geopositioning technologies to manage medical equipment and devices as a "fleet," ensuring that the requirements of medical or surgical procedures are met in the most efficient and expeditious way	Enables more effective anticipation and diagnosis of potential asset fault conditions to minimize downtime and to ensure transparency into mobile asset locations Metrics: Asset availability and access, maintenance cost, and procedure delay time

TABLE 1

Asset and Operations Optimization by Industry

Industry	Use Case Description	Real-Time Asset Optimization	Real-Time Operational Optimization	Benefits over Traditional Approach
Oil and gas	Real-time monitoring of drilling, including predictive analytics for conventional and unconventional drilling activities (shale gas, tight oil, oil sands)	Use of predictive analytics applied to drill head data to warn of potential drill bit failure	Use of predictive analytics and simulation applied to drill head and subsurface data to guide drilling based on identification of obstructions, deviations from reservoir modeling expectations	Enables more effective anticipation and diagnosis of potential drill bit failure, minimize risk of stuck pipe, or dry "frack" Metrics: Nonproductive time, rate of penetration (ROP)
Power and water	Real-time monitoring of distribution lines and equipment, using predictive analytics to proactively address outage risk	User of predictive analytics applied to transformers to warn of potential failure, especially in the case where replacement equipment is custom manufactured	Apply analytics to distribution line sensor data (fault current, wave form, voltage) in conjunction with SCADA/distribution management system data to perform characterization of anomalies and root cause analysis	Reduced outage frequency and duration, reduced line loss to improve grid efficiency and performance Metrics: SAIDI (System Average Interruption Duration Index), SAIFI (System Average Interruption Frequency Index), power quality
Transportation	Equipment- and vehicle-based sensors monitoring asset condition and usage in real time — levels of both usage and "abusage" — linked to predictive analytics to determine proactive maintenance of the transportation asset and fleet	Equipment and vehicle visibility and real-time monitoring to enable preventive maintenance and improved asset reliability, utilization, and performance; includes the deployment of anticipated spare-parts requirements to minimize downtime (Focus here is on maintenance and performance of the individual asset.)	Fleet management visibility and real-time monitoring to ensure business performance and proper adherence to operating regulations; the ability to quickly assess equipment failures enabling rapid deployment of backup capabilities to seamlessly meet business requirements as well as ensuring operating regulations are met (i.e., OSHA)	Enables more effective anticipation and diagnosis of potential asset fault conditions to minimize downtime and reduce business or service disruptions Metrics: Asset availability, operating efficiency, and maintenance cost

Source: IDC, 2014

AN OPERATIONAL TECHNOLOGY PLATFORM: GE'S PREDIX

GE and its partners, drawn from many industrial sectors and disciplines, have built an operational technology platform that optimizes assets and operations as described in Table 1. Predix is GE's software platform for the Industrial Internet. Deployed on machines, on-premise, or in the cloud, Predix combines an industry-leading stack of technologies for distributed computing and Big Data and analytics, asset management, machine-to-machine communication, and mobility. Solutions are being built by GE and its partners, initially for GE's industries and GE-produced machines, and cover high-value processes for asset and operations optimization such as the following:

- Asset optimization
  - Parts inventory management
  - Monitoring and diagnostics
  - Condition-based maintenance
  - Outage management
  - Asset life-cycle management
- Operations optimization
  - Fuel consumption optimization
  - Emission management
  - Regulatory compliance
  - Health and safety assurance
  - Network throughput optimization

Predix: Machine Intelligence for Operational Technology Solutions

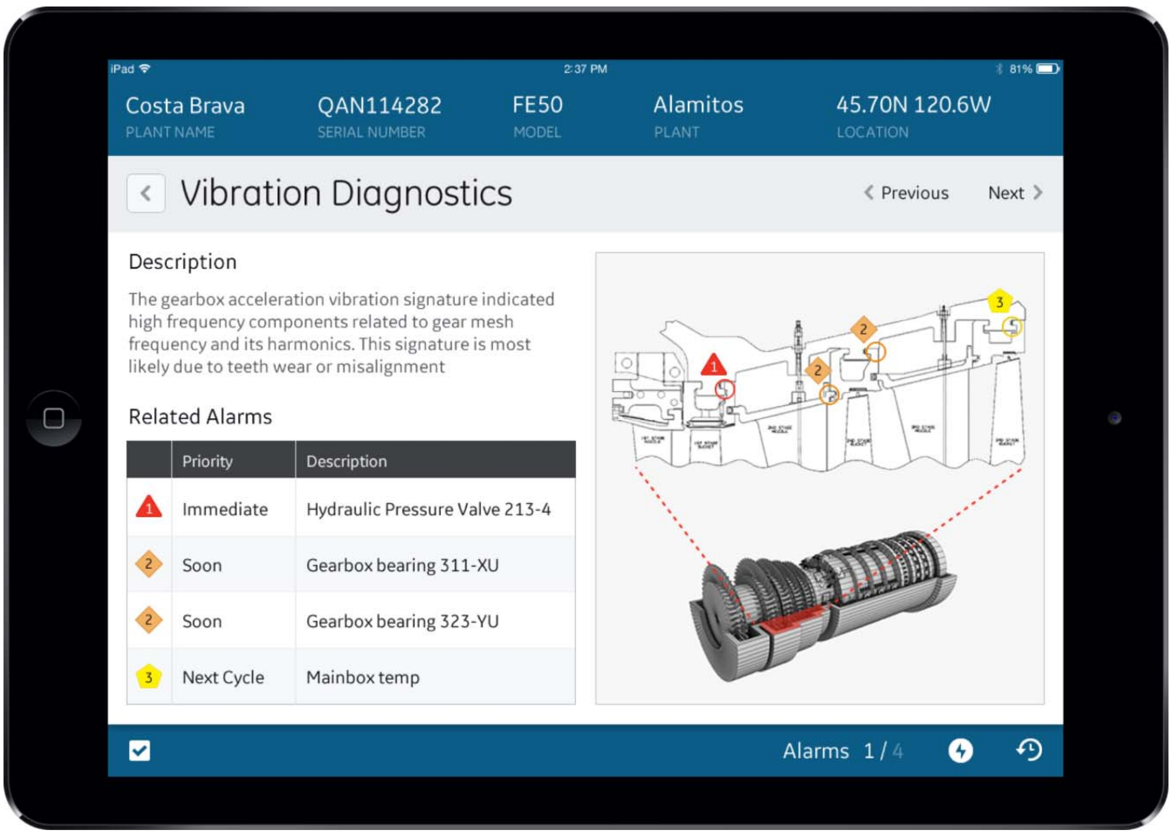
Predix is optimized for the operational technology environment where machines are connected and controllable in an M2M networked environment. A key innovation from GE is the ability to address a device as a "software-defined machine" (SDM). This is a layer of abstraction that can be addressed by a developer using a familiar programming interface. This approach masks the low-level interface that is specific to custom hardware. It also enables GE to make changes to the hardware in a device without breaking the asset-intensive application, as long as the abstraction layer remains constant after the upgrade. So this mechanism both simplifies development and provides a path for continued innovation on the device as well as applications that address the device.

Predix: User Experience for Operational Technology Solutions

The Predix platform enables solutions with a consistent user experience across devices, enabling operations professionals to focus on information related to their responsibilities. This makes individual professionals and teams more productive. Figure 3 illustrates this approach, helping a real-time operator focus on anomalies in the operations process that require attention.

FIGURE 3

GE Predix: User Experience Example



Source: GE, 2014

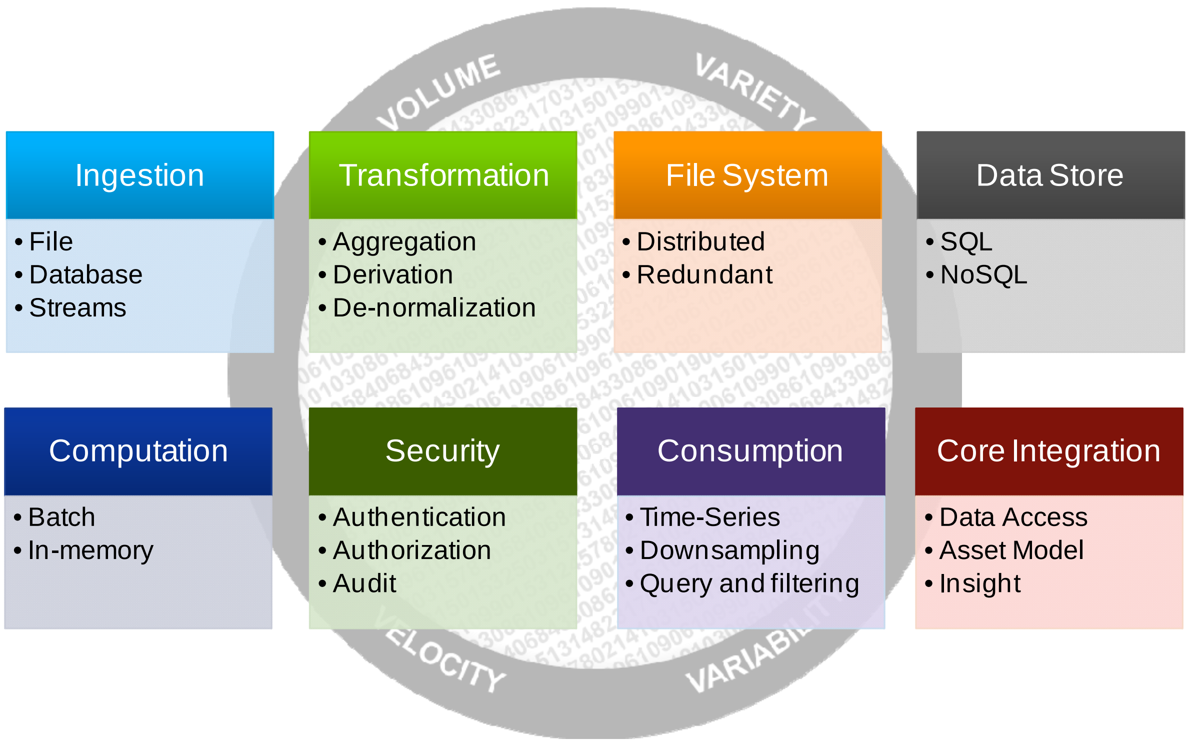
Predix: Data Management for Operational Technology Solutions

Predix is engineered to take in rapidly (using parallel technology) and manage the large and diverse data sources — structured, semistructured, and unstructured — that characterize the Industrial Internet. GE has made an investment in Pivotal, an entity developing a Hadoop, NoSQL, and relational platform for extending the bounds of conventional data management. Connectors have been prebuilt for enterprise sources (such as popular enterprise asset management programs) and machine data for the variety of GE devices. Data models are built to support a variety of asset optimization and operations optimization solutions.

Figure 4 illustrates the Predix capability, which builds on the Pivotal technology. It is an implementation that speaks to the data management platform convergence, which IDC believes is critical to enabling Big Data and analytics applications for operational technology.

FIGURE 4

Enabling Discovery to Consumption of Big Data Using Predix



Source: GE, 2014

Predix: Analytics for Operational Technology Solutions

Predix supports analytics that scales to address Big Data sets applied to operational technology processes involving connected devices over the Industrial Internet. These include reporting and analysis, real-time monitoring and alerting, and predictive models. More than a toolset, applied models such as predictive maintenance have been built and can be extended or customized to fit the unique requirements of each asset-intensive industry. Given the scale of the data that the models use, there is the option to bring the analytical model to the data as well as bring the data to the model for execution.

Predix: Secure Deployment for Operational Technology Solutions

Predix is a platform that has been designed to develop secure operational technology applications. From a deployment perspective, Predix is "cloud agnostic," meaning that the applications can run in a choice of cloud infrastructures (public or private) to meet the needs or preferences of the customer.

FUTURE OUTLOOK

Billions of machines are connecting to the Internet, whether in the home, the plant, or the office. These devices are then controllable so that now applications on mobile devices enable users to view settings on the machine and revise those settings. Think of a thermostat that can be controlled from an iPhone or Android app. That's convenient, but there is a way to go in order to have an intelligent device. That requires the ability to analyze the machine's sensor data in order to understand its actual operation (i.e., historical reporting). The provisioning of the data for analysis enables the building of a predictive analytic application that recommends or automatically adjusts settings to achieve an optimum result (e.g., meeting heating needs for the least cost). At that point, the machine (or asset) becomes intelligent, and it becomes a building block of an intelligent process that can be optimized. This can apply to a thermostat, a pump, and a drill as well as the processes in which these assets are deployed.

With the clear benefit of building intelligence into machines and optimizing the processes in which connected machines are deployed, what is holding back deployment? IDC surveys, as previously noted, point to asset and operations optimization as one of the leading Big Data and analytics initiatives. So the demand is there. What is missing is the supply of industry-specific solutions that can make machines and the processes in which they are deployed *intelligent.* And what is holding back the availability of such solutions? There are multiple factors. Consider the complexity of harvesting the machine data, the skill needed to build the analytical models and applications, and the capability to securely deploy the solutions. Platforms specialized for the development and flexible deployment of operational technology solutions will help accelerate getting more solutions to market. Security and data integration are IT skills. An operational technology platform built with IT rigor helps to bridge the traditional divide between IT and OT. The need is clear, and we will see the alignment of the supply to meet the demand.

Once solutions become more readily available, a familiar pattern should emerge. Successful implementations will provide reference to the next set of customers and the market will expand. Who will supply the solutions? We will see new companies getting into the business of providing analytics-driven services. The manufacturers that produce the machines and already provide break/fix maintenance services (and therefore have access to the machine data and the repair data) will build out solutions that are predictive and offer higher value services to their customers.

This is already happening. Product companies are extending their service offerings powered by predictive analytics that leverage the rich data coming out of Internet-connected machines. Product companies, like GE, have the data, and they have existing relationships with customers (from asset-intensive industries) and partners that can be expanded.

CHALLENGES/OPPORTUNITIES

The opportunities are huge for manufacturers and service companies (health, utilities) to provide value-added services like predictive maintenance. The friction is the complexity of building these solutions given the lack of standards, the custom/unique interfaces in communicating with the machines, the unique formats of the data coming from the machines, and so on. But the economics (high incremental value of such services) will push the industry to overcome these barriers.

Today the technical challenges are significant given the diversity of devices and the lack of standards. GE's program begins with GE machines produced by the major GE divisions – Aviation, Energy Management, Healthcare, Oil & Gas, Power & Water, and Transportation. Existing GE customers can look to GE to provide higher order services, like predictive maintenance, to protect their investment in GE equipment. But a buyer is likely to want more and will push GE to cover not just GE machines but also machines of the same type from another manufacturer. The buyer's opportunity in asset and operations optimization will come from the optimization of any of the machines on which the buyer relies, whether from GE or from another company.

GE will need to work with its customers to help enable the expansion of Predix to cover non-GE assets. At some point, GE will need to expand its approach so that non-GE machines can be set up as "software-defined machines." This would enable both GE- and non-GE-connected machines to be accessed and analyzed in a consistent way from both a development perspective and an operator perspective.

As a further step, GE is taking the initiative to address the lack of standards across machines by forming the Industrial Internet Consortium (IIC) with AT&T, Cisco, IBM, and Intel. The IIC is managed by the distinguished standards body – the Object Management Group. The goal of the consortium is to develop standards and reference architectures for review and to encourage sharing of use cases, best practices, and lessons learned.

CONCLUSION

Does Big Data from the Industrial Internet lead to added business value? To answer this question, we must add another "V" to the definition of Big Data – "value." The only reason to monitor and analyze Big Data is when the initiative yields incremental *value* to the business over and above the increased effort (and cost) to manage and analyze these more complex data sets.

For example, the setting of maintenance priorities for production assets is a high-value decision given the level of expense to the enterprise for the maintenance operations and the cost to the enterprise when asset failure causes service disruptions. But is the mining of sensor data relevant? If taking account of this machine data can improve the accuracy of predictive models for asset reliability, then such data is relevant and the initiative can deliver value. Organizations are finding that predictive maintenance analytical models can guide managers to better decisions on how to deploy assets and when to maintain them to ensure safe, efficient, and optimized operations.

To capture value from analytics on connected things or machines:

- Focus on high-value decisions and then take advantage of all relevant data.
- Ensure that new applications meet the requirements of the 3rd Platform: cloud deployable, mobile-centric interfaces, and incorporate Big Data and analytics.
- Look to a new generation of applications that leverage data from connected machines in order to optimize high-value asset and operations decisions.

To accelerate deployment of intelligent applications for the Industrial Internet, consider solutions built on platforms that have been pre-specialized for operational technology use cases like GE's Predix.

About IDC

International Data Corporation (IDC) is the premier global provider of market intelligence, advisory services, and events for the information technology, telecommunications and consumer technology markets. IDC helps IT professionals, business executives, and the investment community make fact-based decisions on technology purchases and business strategy. More than 1,100 IDC analysts provide global, regional, and local expertise on technology and industry opportunities and trends in over 110 countries worldwide. For 50 years, IDC has provided strategic insights to help our clients achieve their key business objectives. IDC is a subsidiary of IDG, the world's leading technology media, research, and events company.

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