WHITE PAPER

INTELLIGENT BUSINESS STRATEGIES

Asset Intelligence for Smart Manufacturing

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tellmeplus
Predictive Objects

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WHAT IS INDUSTRIAL IOT AND WHAT DOES IT MEAN FOR MANUFACTURING ASSET INTELLIGENCE?

Many manufacturing organisations are deploying sensors in their manufacturing production line equipment as part of a digital transformation programme

Many manufacturing organisations today are undergoing transformation to become smart digital manufacturing companies. At the heart of digital transformation is the deployment of sensors in manufacturing production line equipment and in other assets to enable the collection and analysis of data (both in real-time and offline) to help optimise operations, maximise asset performance, boost production and reduce risk. The use of sensors inside manufacturing equipment has turned assets into connected and smart assets which are also known as the industrial internet of things (IIoT).

Sensors are being used in assets to help optimise manufacturing processes

IIoT is however much more than just assets that include sensors to collect data. IIoT in manufacturing is about the use of IoT technologies together with analytics to effectively optimise manufacturing and distribution processes. In that sense, IIoT is also about data collection, data communication, data preparation and data analysis using trained machine learning, *predictive analytical models* that can run either in or close to wherever these assets are running. Furthermore, it can include rules engines which can be used together with machine learning models to build *prescriptive analytics* which, with the help of Industrial IoT platforms, can be deployed in manufacturing operations. Prescriptive analytics go further than predictive models. This is because they can be used to automate decisions and actions in near real-time and also offline in-batch analysis. Automated decisions and actions are used to help optimise operations, reduce risk, prevent downtime and guide business experts working in operational roles to make the right decisions at the right time to keep manufacturing processes running smoothly.

Deploying prescriptive models in manufacturing allows decisions to be automated to help optimise operations, reduce risk, prevent unplanned downtime

They can also be used to guide people to make the right decisions at the right time

Asset data together with analytics can be used to prevent unplanned equipment failure and associated costs

It can also be used to improve asset performance, reduce losses and help shop-floor personnel work smarter

Manufacturing equipment can be monitored in real time

Why is this so important to manufacturers? There are many reasons. Manufacturers may need to operate on a 24 x 365 basis which means that preventing unplanned equipment failure or product non-conformity is critical. Having access to IIoT data and analytics built into the asset makes it possible to monitor live operations and predict the likelihood of events (defaults, failures, production increases...). This means that manufacturers can schedule preventive actions and avoid the downtime and reactive maintenance problems caused by unplanned failures or production demand. IIoT is also important in helping to maximise the performance of equipment in the manufacturing process and allow people to work smarter. It also helps to improve on quality. Poorly performing and unreliable equipment can slow process activities and contribute to unplanned operational costs, sup-optimal production, re-work, poor quality, delays and late deliveries. All of this eats into profits, restricts growth and in the worst cases could lead to loss of business if customer satisfaction is severely impacted. In addition, the need to improve health and safety and lower operational risk is paramount in manufacturing environments. Being able to monitor equipment in real-time and acting to preventing equipment failure can also improve on health and safety in manufacturing operations and better use of resources.

Looking at all of this, it is clear that Asset Intelligence - the combination of Industrial IoT, artificial intelligence and analytics can be a ‘game changer’ in manufacturing and asset performance. Let’s look at this in more detail.

ASSET INTELLIGENCE MANAGEMENT

KEY ASSET MANAGEMENT CHALLENGES IN MANUFACTURING TODAY

There are many challenges to overcome when managing assets

Manufacturing today, faces a number of key challenges with respect to managing their assets. This includes:

- Maximising asset performance to increase production rates and get the most value from their equipment
- Keeping assets and operations running 24x365
- Preventing unplanned asset downtime and related operational costs caused by asset failure
- Learning from events and problems that occur on any asset but that can happen on any other asset of the same class/category
- Optimising field service operations by knowing when to schedule maintenance of which assets in order to keep them in service and running optimally
- Identifying manufacturing process problems before they happen (e.g. bottlenecks, process task delays), anticipating their impact and acting to minimize risk
- Dynamically changing asset run rates in-step with demand
- Improving product quality to reduce unplanned losses and non-conformity
- Improving health and safety for manufacturing operations personnel
- Improving workforce productivity and responsiveness
- Maintaining the right inventory levels and optimise the supply chain

Maximising asset performance to increase equipment ROI

Preventing unplanned downtime due to failure

Optimising field service to minimise maintenance costs

Need to improve product quality to minimise losses

Help shop-floor personnel work smarter

These challenges get harder as organisations grow and become more complex. This is also true as more automation is introduced because the manufacturing process accelerates. The faster the throughput, the greater the need to access and analyse near real-time data so that applications and business experts can act quickly to resolve problems and minimise disruption. No-matter how you look at it, these challenges are behind the increasing demand for IIoT data and analytics in manufacturing.

THE BENEFITS OF CAPTURING AND ANALYSING ASSET OPERATIONS DATA

A key aspect of digital manufacturing is deploying telemetry in assets to capture data for analysis

The benefits of deploying telemetry in assets, capturing IIoT data and analysing it are significant. It means that manufacturers can measure and predict manufacturing operational performance which allows them to respond and act in a timely manner when unplanned events are predicted or occur, when changes in demand are predicted to prevent high risk and sub-optimal business conditions from disrupting operations.

Telemetry makes it possible to analyse asset performance in real-time

It allows companies to monitor asset performance and even simulate critical path machinery. Simulation can be done by creating an exact digital representation of a physical running asset (see Figure 1). Having data that provides this kind of capability allows manufacturers to simulate asset operation and performance

at specific points in time (past or future) and in real-time on a continuous basis. This allows asset intelligence to be built up to understand performance at different levels of throughput. IIoT and analytics therefore makes it possible for manufacturers to continuously monitor operations, predict events, optimise asset performance and guide people.

Asset simulation makes it possible to understand asset performance at different levels of productivity

Predict asset failure, understand equipment conditions that lead to failure and schedule preventative maintenance

Improve personnel health and safety

Source: GE.com https://www.ge.com/reports/twinsies-digital-twin-wins-accolades-tames-factory-operations/

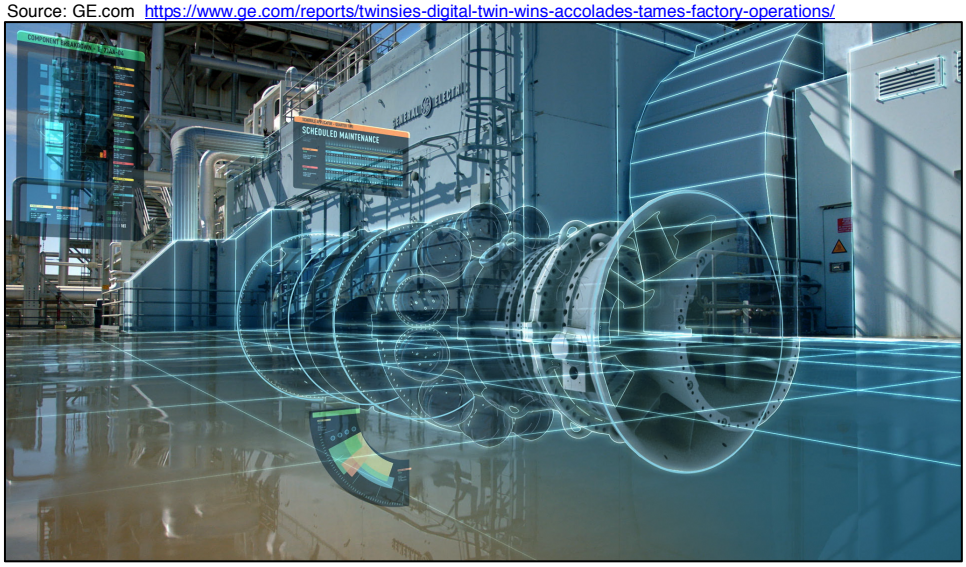

Figure 1 – Asset Simulation

Measure and predict product quality, identify repetitive failures and their causes

Capturing and analysing asset operations data can therefore help improve asset performance and availability or can also lead to increased production rates at higher quality and lower cost. This should help eliminate or significantly reduce losses caused by downtime, poor quality, poor production rates and loss of valuable operating time. Also employee's health and safety can be improved and operational risk can be lowered.

Reduce losses caused by downtime, poor product quality, poor production rates

Manage inventory levels better

Collecting and analysing IIoT data means detailed asset intelligence can be produced to measure *and predict* asset reliability, types of downtime and their duration, equipment conditions, daily production, product quality and the number of rejected products. You can also measure and predict specific functional failures, mean time between failures as well as identify repetitive failures, causes of dominant failure and the impact of failure on health, safety and inventory. It allows manufacturers to assess their own vulnerabilities by analysing reliability and performance of critical assets.

Build reputation and quality of brand as a modern digital manufacturer

Being able to improve quality, guarantee product/service conformity, alert the right people at the right time, minimise failure and improve health and safety all contribute to lowering and managing risk. It also helps build customer satisfaction, hence brand reputation and loyalty. That together with reduced maintenance costs and better productivity results in optimised and smart manufacturing operations.

WHAT'S REQUIRED TO ANALYSE ASSET GENERATED DATA?

Given these worthwhile business benefits, what is required to analyse data generated by manufacturing assets? There are several things that need to be in place to do this. They include:

IoT platforms are needed to automatically discover manufacturing assets and connect them to the enterprise

- An IoT platform - software that is used to manage and connect manufacturing assets and data to the enterprise. They are needed to:
  - Automatically discover, classify and register industrial IoT assets and/or gateways that collect data from these assets for analysis
  - Define and/or automatically discover, catalog and manage schema for data emitted by each type of registered industrial asset
  - Automatically detect new, upgraded and no longer online assets in the network together with any changes to asset data schema

Asset telemetry data needs to be transformed and integrated with enterprise data to ready it for analysis

- The ability to create a data lake or data repository in the cloud or on premise to store asset data
- The ability to prepare and integrate raw data from multiple sensors in a single industrial asset and multiple assets for analysis to understand how assets are performing in a manufacturing process

Master data is needed in addition to asset performance data when managing manufacturing operations

- The ability to integrate raw asset data with enterprise data (e.g. asset master data) and exogenous data at the edge, centrally on a cloud or in a data centre
- The ability to manage master data (e.g. materials, asset, product) at the edge to apply context during manufacturing asset performance analysis

Time-series analysis is also needed within the context of work shifts

- The ability to divide up the data into one or more time windows (e.g. 5 minutes, 10 minutes) and logical time periods (e.g. an 8-hour work shifts to compare what happens from shift to shift) to set boundaries within which time series analysis will take place
- The ability to define business conditions (e.g. in a manufacturing process) indicated by patterns in the data, business expert / field knowledge or expertise that need to be automatically detected during manufacturing asset operations

Machine learning automation helps shorten the time to develop predictive and prescriptive models needed to optimise manufacturing operations

- The ability to develop and/or automate development of analytical models either on-premises or in the cloud for deployment to run in or close to industrial assets to monitor, detect business conditions and predict asset performance, propensity to fail in real-time etc.

Need to deploy models to monitor assets in real-time

- The ability to automatically deploy newly developed predictive and prescriptive models to run in real-time on edge gateways and in industrial assets to look for patterns in the data on a 24x365 basis within defined logical time windows that would indicate or predict a business condition

- The ability to deploy newly developed predictive and prescriptive models to run centrally in batch to look at generated manufacturing asset data over longer periods of time (e.g. a few months) to identify cause of repeated asset failures, repeated health and safety risks or repeated losses due to poor product quality

- The ability to manage all many analytical models and model versions deployed and running in enterprise manufacturing operating environments

Rules need to be defined to automate manufacturing decisions and actions

- The ability to define and manage rules for remote execution of prescriptive models in manufacturing asset operations including support for rule version control and rule parameters

- The ability to activate and de-activate edge rules used to drive alerts and automated actions in manufacturing operations

Model management and version control of models deployed in the manufacturing process is critical

- The ability to define business conditions (rule combinations) upon which actions should be taken during manufacturing operations

Need to automate actions to optimise operations and minimise risk

- The ability to define the actions to take to optimise asset performance, prevent asset failures and minimise health and safety risks if a business condition is detected

- The ability to visualise asset performance in real-time (e.g. situational awareness dashboards) and over longer time periods

Need to alert and guide the shop floor to enable them to work smarter

- The ability to define who should be using and leveraging the results of analytics in the manufacturing process to optimise operations (e.g. shop floor supervisors, asset operations managers, production line asset operators, field service personnel, robotic applications etc.) and thus have a tool that can adapt to the expertise of users

- The ability to replay asset performance data e.g. to see the conditions leading up to an asset failure, pinpoint product quality causes or to see what actions were taken last time a condition occurred and on what work shifts (if any) these anomalies predominantly occur

- The ability to track automated and manual actions to provide an audit trail for governance and to understand what action(s) were taken and why

Analytical models used to predict asset performance and asset failure need to be automatically monitored and retrained if they become stale

- The ability to filter, reduce and send deviations in asset data to a cloud or a data centre for further offline analysis

- The ability to automatically monitor the accuracy and drift of models deployed at the manufacturing asset operations, update real time models with new events/data and trigger automatic re-training and re-deployment of these models if accuracy drops below acceptable thresholds

An owner of an asset performance analytics programme is needed to coordinate analytic activity

In addition, it is important to appoint an owner of an asset performance analytics programme responsible for defining, prioritising model development and aligning with business strategy to maximise business benefit e.g. for preventive maintenance of assets, maximising throughput and avoiding unplanned operational cost. They should also be responsible for managing the development, deployment and monitoring of manufacturing edge-based analytics and for integrating production line

analytics with central analytical environments to enable development of analytical models that can run in-stream (in real-time), in-Hadoop, in-memory and in database for end-to-end analysis of core manufacturing problems.

THE VALUE OF DEVELOPING AND DEPLOYING ASSET INTELLIGENCE ANALYTICS USING TELLMEPLUS

Having understood the challenges, benefits and requirements associated with asset management / intelligence in a manufacturing environment, this section of the paper looks at how Tellmeplus Predictive Objects can be used to help organisations get the most out of their assets.

TELLMEPLUS PREDICTIVE OBJECTS

Tellmeplus Predictive Objects is a machine learning automation platform designed to accelerate development and deployment of analytics used in manufacturing operations

Tellmeplus's flagship product is Predictive Objects which is aimed at business experts. Predictive Objects is a machine learning automation software platform that uses artificial intelligence and automation to speed up development of predictive and prescriptive analytical models. It can also automate the deployment of these models to industrial assets and edge device gateways to continuously analyse and act on IoT data in real-time. Model deployment is done in conjunction with industrial IoT platforms. In addition, Predictive Objects can be used to deploy models centrally for offline analysis of industrial asset generated IoT data. Furthermore, Predictive Objects can manage the complete lifecycle of machine learning models by automatically monitoring the accuracy of deployed predictive and prescriptive models and trigger retraining and re-deployment of any models where accuracy has dropped below user defined thresholds. This keeps models fresh and fit for purpose in everyday manufacturing operations.

Automated Model Development

Tellmeplus Predictive Objects organises model development into projects

Looking at Predictive Objects in more detail, development of a new model (e.g. to predict the propensity of an industrial asset to fail) starts by first creating a project.

Source data is imported into Hadoop HDFS

Automatic data discovery helps business experts quickly understand source data

Time-series calculations can be done during data preparation to create a stronger data set for use in training predictive models

Within a project, business experts can define one or more data sources from which data is taken and prepared for input into a model algorithm. Source data is imported into and persisted in Hadoop[1] HDFS from where Predictive Objects automatically discovers, profiles, infers schema and displays statistics about the data to speed up the ability to understand the data available. The ability to support multiple sources in a project means that both univariate[2] and multi-variate[3] analyses are possible. In the context of asset management, asset telemetry data is typically time-series oriented and so Predictive Objects allows business experts to define time windows on the data and time series calculations to be done at runtime on data within the window to add useful new data to a dataset prior to that data being fed into an algorithm. This helps improve

[1] Hortonworks HDP is bundled with Predictive Objects

[2] Univariate analysis looks at data from a single data source (e.g. a temperature sensor) to identify patterns

[3] Multi-variate analysis is looks across data from multiple data sources (e.g. temperature sensors, pressure sensors, asset master data etc.) to identify patterns

accuracy and also allows Predictive Objects to train models that can detect and predict more complex business conditions indicated by patterns and derived calculations. This is especially important when data is coming from multiple data sources. Also multiple time windows can be defined on data which allows business experts to look for one or more patterns in the data at the same time.

Asset event sequences can be defined to define patterns in the data that denote a business condition

In addition, it is also possible to define sequences of events that indicate a pattern in the data that represents a business condition.

Predictive Objects automatically generates, trains, tests and evaluates predictive models, comparing accuracy before recommending the best model

Once this is done, Predictive Objects automatically runs a simulation process: it generates many algorithms and uses them to train, test and evaluate multiple models passing the prepared data into different algorithms to determine the best model. Business experts can manually configure how long this process runs for by selecting a small, medium or large simulation. Small simulations are good to get an overview of model performance. However, medium and large simulations will produce a more accurate models but will run for longer. At the end of the simulation process, Predictive Objects shows the evaluations of all the models generated together with the most important data attributes contributing to the prediction. It also provides visualisations to such as lift curves, ROC curves and model metrics to explain the accuracy of each model it generated. A predictions chart is available to show the times when business conditions associated with a specific asset or in the broader manufacturing operation were predicted. Finally, it also recommends the best model. The result is not only rapid development but also a relatively easy way to compare multiple models to understand why Predictive Objects has recommended a particular model as the best one. These automation and explainable artificial intelligence capabilities help to significantly shorten the development process.

It can also explain model accuracy by indicating the relative importance of each attribute to a prediction and by providing visualisations to see accuracy at a glance

Model Deployment

Predictive Objects can also automate model deployment to manufacturing assets and industrialise the deployment process with the help of IoT platforms

Once the best model has been selected, Tellmeplus Predictive Objects can be used to automatically deploy the model to run in real-time at the edge of the network either within one or more specific industrial assets that need to be monitored or on an edge gateway device located near the asset(s) that collects data from it/them. To deploy a model, Predictive Objects 'pushes' the model into production by creating a REST API to it. It can be deployed in a Docker container to run in any cloud environment (e.g. in a Kubernetes cluster) or deployed in an edge gateway device (e.g. a Cisco router by generating Cisco Go code) or an asset. Single model deployment can be done by Tellmeplus. However industrialised deployment of models to many different assets is done in conjunction with IoT platforms. IoT platforms that Tellmeplus supports include Cisco Kinetic, GE Predix, Siemens Mindsphere, Microsoft Azure IoT and Google IoT Core.

Several IoT Platforms are supported

Automated Management and Monitoring of Edge Analytics

Predictive Objects can automatically monitor the accuracy of deployed asset based analytics and trigger automatic retrain and redeployment when accuracy drops below user defined thresholds

Once models have been deployed, Tellmeplus Predictive Objects can continue to manage and monitor their accuracy. This is done by setting accuracy thresholds to monitor models against. Model accuracy is then continuously measured and when it drops below a set threshold, Predictive Objects can automatically trigger retraining and redeployment to keep models fresh and fit for purpose in a manufacturing environment.

ASSET INTELLIGENCE USE CASE – PREVENTIVE MAINTENANCE

A large industrial organisation needed to monitor conditions and root cause to schedule maintenance to prevent failure in its mission critical assets

One example of Tellmeplus Predictive Objects in action is in a large industrial conglomerate that produces electrical power units for their clients to use to power heavy, mission-critical industrial equipment such as pumps, conveyors, etc. These power units needed to be monitored to look for conditions and their root cause that would signal the need for preventative maintenance to avoid failures.

The process of collecting and analysing data to predict asset failure and trigger preventive maintenance took weeks

Although installed power units are subject to regular preventive maintenance actions performed by certified engineers, the process of collecting and analysing failure data from the power units' black boxes to determine if scheduled maintenance tasks was needed, could take up to several weeks. This is because the failure detection to resolution process was totally reliant on the availability of experts who needed to regularly go onsite to perform this process.

Predictive Objects was able to automate this task, performing root cause in a matter of seconds

The company was looking to increase the reliability of a certain class of these units, in order to cut operational costs and optimize delivery of maintenance service. During an initial round of testing, Tellmeplus Predictive Objects analysed historical data to perform root cause analysis, successfully passing a 'blind test' to classify and explain every past failure in a few seconds. This proof of concept enabled tests of the solution against a real-world predictive analytics use case, with real data and users.

It is now being used to manage preventive maintenance service operations for all power units of this class

Tellmeplus Predictive Objects is now being implemented in all units from this class, managing service operations for preventive maintenance and increasing the performance and availability of systems for customers.

CONCLUSIONS

OVERALL BUSINESS BENEFITS OF THE TELLMEPLUS SOLUTION

Industry use of IoT data gathered from asset telemetry is growing rapidly in manufacturing

As more and more manufacturers look to streamline their business operations, maximise productivity and minimise risk, we are seeing a major increase demand for industrial IoT telemetry to capture the data needed to monitor manufacturing production asset performance to improve asset availability and process efficiency while running at minimal costs.

Deploying predictive and prescriptive analytics in the production process enables the monitoring and optimisation of manufacturing operations

Deploying analytics in the manufacturing process itself allows companies to monitor the pulse of manufacturing in real-time as well as act to prevent failure, optimise field service and dynamically re-allocate production resources in a timely manner when changes occur. It also allows organisations to simulate asset individual asset performance at different levels of throughput, understand the implications of stressing assets at maximum production levels in terms of the impact on health and safety, propensity to fail and other parts of the manufacturing process. All of this helps to optimise manufacturing production processes and make them become smart. Bottlenecks in the manufacturing process can be predicted long before they become a problem. Work shifts can be analysed and causes of product quality pinpointed. Also, in cases where large numbers of assets need to be managed it means that potentially thousands of models will need to be developed, deployed, continuously monitored and managed across global manufacturing operations. The only way to handle this complexity is via a machine learning automation platform.

Tellmeplus Predictive Objects automates the development, deployment, monitoring and retraining of analytics used in digital manufacturing operations

Tellmeplus Predictive Objects is an example of such a platform. It can be used to manage the entire model lifecycle accelerating model development and automating deployment in manufacturing assets. This speeds up projects delivery and reduces time to value. Once deployed, models become analytical assets of the company. In addition, Tellmeplus Predictive Objects can automatically monitor all analytical models that have been deployed in manufacturing operations retraining and redeploying them when their accuracy levels drop below acceptable levels. It is this industrial approach to end-to-end model lifecycle management that makes Tellmeplus a serious contender in helping organisations reduce time to insight, conquer complexity and confidently manage and maximise asset performance in an end-to-end manufacturing process.

About Intelligent Business Strategies

Intelligent Business Strategies is an independent research, education and consulting company whose goal is to help companies understand and exploit new developments in business intelligence, machine learning and advanced analytics, data management, big data and enterprise business integration. Together, these technologies help an organisation become an *intelligent business*.

About Tellmeplus

In every organization, efficiency depends on how well assets and processes are being used and leveraged. Predictive Objects helps businesses utilize AI to dramatically improve their efficiency and performance by embedding intelligence in every critical asset. The SaaS platform leverages machine learning, AI and big data to automate the creation and deployment of predictive models for faster, more accurate predictions, in order to achieve ubiquitous asset intelligence.

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Asset Intelligence for Smart Business