IBM Predictive Solutions Foundation on Cloud
Last updated: 2016-03-04

User Guide

Note

Before using this information and the product it supports, read the information in “Notices” on page 87.

Product Information

This document applies to Predictive Solutions Foundation on Cloud and may also apply to subsequent releases.

Contents

Chapter 1. Welcome to IBM Predictive Solutions Foundation on Cloud

What is IBM Predictive Solutions Foundation on Cloud?

IBM® Predictive Solutions Foundation on Cloud is a cloud-based solution that enables operations, manufacturing, production, and maintenance personnel in asset-intensive industries to employ predictive analytics to improve asset availability, increase throughput, minimize unplanned outages, and reduce maintenance costs.

IBM Analytics Solutions Manager on Cloud is an application that provides the user interface for Predictive Solutions Foundation on Cloud that enables you to load data, analyze that data, make and test predictions, and preview reports and dashboards.

IBM Predictive Maintenance on Cloud

Predictive Maintenance on Cloud is a feature of Predictive Solutions Foundation on Cloud that looks for patterns in how an equipment asset is used and the environment in which it is operating. It then correlates this information with any known failures in the equipment. These correlations are used to evaluate new data about the equipment asset, resulting in predictive scores that indicate the relative health of the equipment and the likelihood of future failures.

The ability to determine when maintenance should be performed on equipment assets leads to the following business benefits:

- You can estimate and extend the life of your assets.
- You can increase the return on your assets.
- You can optimize your maintenance, inventory, and resource schedules.

Predictive Maintenance on Cloud goes beyond both preventive and regularly scheduled maintenance to ensure asset performance, thereby enabling maximized value at every step of a process. Using Predictive Maintenance on Cloud, you can perform the following tasks:

- Predict the failure of an instrumented asset so that you can prevent costly unexpected downtime.
- Make adjustments to predictive maintenance schedules and tasks to reduce repair costs and minimize downtime.
- Determine the most effective maintenance cycles.
- Identify the root cause of asset failure faster so that you can take corrective actions.

Instrumented assets generate data such as device ID, timestamp, temperature, and status code.

Examples of instrumented assets are manufacturing equipment, mining equipment, drilling equipment, farming equipment, security equipment, cars, trucks, trains, helicopters, engines, cranes, oil platforms, and wind turbines.

Data from instrumented assets and data from other sources such as maintenance records, maintenance logs, inspection reports, repair invoices and warranty claims can be collected and used in models that predict when an asset is likely to fail.

Predictive Maintenance on Cloud helps an organization optimize its maintenance program by developing a set of recommendations to carry out when specific changes in asset health are identified. These recommendations can be based upon analysis of historical maintenance records, best practices and procedures provided by subject matter experts, original equipment manufacturer recommendations, as well as analysis of correlations that indicate potential problems or pending asset failure. The goal of developing these optimized decisions or recommendations is to further improve maintenance practices. When an anomaly in asset performance is identified specific recommendations can be made to maintenance personnel in order to affect the most efficient remedy of the problem. In the case of a manufacturing organization which provides service or warranty support for products that are used by hundreds or thousands of customers, the ability to monitor asset performance in the field and proactively initiate a service call, in comparison to waiting for the client to initiate a repair request or warranty claim, can significantly transform the way the manufacturer provides service. With a better understanding of asset usage and performance in the field manufacturer may wish to modify its warranty program based upon asset usage or warranty costs. Additionally greater insight into asset usage and performance can help the manufacturer to optimize the parts inventory and locations so as to reduce the volume of inventory and identify locations to facilitate proactive customer service.

For example, an automobile assembly plant is a system that combines thousands of pieces of equipment with interlocking pieces. It is critical that such a system is able to work efficiently and produce safe, high quality products. Predictive Maintenance on Cloud looks for patterns in the usage and environmental information for equipment that correlate with failures that take place. These patterns are used to create predictive models to score incoming new data in order to predict the likelihood of failure. Scores that are generated from this information give an indication of the health of the piece of equipment. In addition, key performance indicators (KPIs) are collected, which are used for reporting. KPIs help to identify assets that do not conform to normal patterns of behavior. The plant employees can use dashboards and reports to monitor and track the lifecycle of each piece of equipment.

IBM Predictive Quality

Predictive Quality is a feature of Predictive Solutions Foundation on Cloud that does the following things:

- Detects unfavorable changes in the quality of components (inspection entity)
- Detects unfavorable changes in variable-type data, and provides information that facilitates diagnostics and alarm prioritization (parametric entity)

IBM Research's Quality Early Warning System (QEWS) algorithm in Predictive Quality detects emerging quality problems sooner and with fewer false alarms than is typically achieved by traditional statistical process control. To achieve earlier detection, QEWS is sensitive to subtle changes in data values, such as shifts that are small in magnitude or trends that grow slowly over time. For a given level of statistical confidence, QEWS typically needs fewer data points than traditional statistical process control.

Early detection of quality problems is essential where delayed detection can have significant negative consequences, such as in the following scenarios:

- Building a large inventory of defective products results in high scrap costs.
- Having widespread quality or reliability problems in the field results in damage to brand value.
- Compromised production of supply-constrained materials or components prevents on-time shipment.
- Compromised production of products with long manufacturing times results in shipment delays.

Inspection entity

In a manufacturing environment, defects can occur in a manufacturing process because of variations in factors like process, raw materials, design, and technology. The resulting low quality of products creates a larger inventory of defective lots, which leads to increased inspection effort.

A small delay in detecting a quality problem can result in large costs, lost opportunity, and lost brand value.

In the inspection entity, QEWS evaluates evidence to determine whether the rate of failures is at an acceptable level. QEWS highlights combinations for which the evidence exceeds a specified threshold. QEWS can detect emerging trends earlier than traditional statistical process control, such as trend analysis. QEWS maintains a specified low rate of false alarms. Post-warning analysis of charts and tables identifies the point of origin, the nature and severity of the problem, and the current state of the process.

The inspection entity analyzes data from the inspection, testing, or measurement of a product or process operation over time. The data can be obtained from the following sources:

- Suppliers (for example, the final manufacturing test yield of a procured assembly)
- Manufacturing operations (for example, the acceptance rate for a dimensional check of a machined component)
- Customers (for example, survey satisfaction ratings)

Products are the subjects of QEWS analyses. A product is typically a part or a part assembly, but it can also be a process or a material. Products might be used in larger finished assemblies, which QEWS calls resources. A product can be associated with any resource, process, material, location, or a combination of these entities during inspection analysis.

You can adjust the frequency at which data is captured and input to QEWS, and the frequency at which QEWS analyses are run, according to the requirements of each situation. For example, monitoring the quality levels of assemblies that are procured from a supplier might best be done on a weekly basis; monitoring the quality levels of units that are moving through a manufacturing operation might best be done on daily basis.

Parametric entity

In the parametric entity, Quality Early Warning System for Variable Data (QEWSV) monitors variable-type data. Variables are defined for every operation per tool. Variables are equated with Measurement type, whose measurements are read at different time intervals during the sequence of the operation flow. This type of data is found in several industrial applications, including Supply Chain, Manufacturing, and Finance applications.

QEWSV identifies unfavorable trends in the data process. The focus is on providing timely detection of unacceptable process behavior while maintaining a pre-specified low rate of false alarms.

Variable values and evidence charts are plotted by using parametric results. The deviation or drift from target values are computed and analyzed to show whether the process sequence is adhering to normal operation limits.

Predictive Quality handles various master data sets, from end products to manufacturing machinery to the raw materials used, as well as environment or location-specific data. Predictive Quality identifies the following sub use cases. Sub use cases can apply to a combination of different masters or to a lone master entity.

Process resource validation
This category is the default use case, where the process and the resource that takes part in the process is monitored based on a defined set of variables. These variables are associated with a set of parameters that define the target values, acceptable limit, unacceptable limit, standard deviation, false alarm rate, and unacceptable factor.

Resource validation
A resource is monitored based on the standard operation limits across a few measurement types (variables). This type of health check is essential in identifying any issues in the resource and correcting those issues to improve the performance and throughput.

Product validation
With Quality inspection, the product as a whole is checked, based on the failure rate. In variable data, given the set of variables whose targets are set for the product to meet, any deviation or drift beyond the allowed deviation highlights a flaw in the product.

Material validation
Raw materials that are purchased from a vendor are monitored for a defined set of guidelines as variables, and validated to check on the quality of the procured material.

Location suitability
With variable analysis, a location is analyzed to see whether it is suitable for a particular operation. Variables like pressure, temperature, humidity, and their time slide values can forecast the suitability of a location for carrying out any operation.

IBM Predictive Warranty

Predictive Warranty is a feature of Predictive Solutions Foundation on Cloud that looks for conditions that lead to accelerated wear and replacement of manufactured products that are under warranty. Such conditions might include variations in the manufacturing process of the product, variations in the quality of vendors' materials that are used in the product, or the ways in which the product is used.

A small delay in detecting the conditions that lead to accelerated wear can cause more warranty claims and related losses. By understanding the factors that lead to warranty claims, you can take corrective actions such as the following actions:

- Improve manufacturing processes to prevent warranty claims.
- Recall faulty products or product batches that have safety implications.
- Set pricing for warranties and extended warranties.
- Evaluate vendors of the materials that are used in the product.

IBM Research's Quality Early Warning System for Lifetime applications (QEWSL) algorithm provides detection that is based on excessive replacement rate and evidence of wear-out.

Replacement rate

QEWS alerts you when the product's random failure rate exceeds a computed threshold. The threshold can reflect product reliability goals (for example, the product population in the field must not exceed a specified failure rate) or financial liability goals (for example, the cost of reimbursing product warranty claims must not exceed a specified total amount).

Wear-out

QEWS alerts you when it finds evidence that product failures are not random in time, but are indicative of wear-out. Wear-out means that products that are in customer use for a longer time fail more often than products that are in customer use for a shorter time. Because wear-out can have serious consequences, QEWS alerts you when it detects evidence of wear-out regardless of how many product units contributed to the detection.

QEWS enables warranty models that are based on sales, production, and manufacturing dates.

Sales model

The Sales model identifies variations in product wear and replacement rates according to the date of sale. The date of sale might correlate with in-service conditions, seasonal climatic conditions, a particular customer, or other important similarities.

For example, a product carries a one-year warranty. In cold conditions, the product becomes brittle and wears prematurely. In certain geographies, products that are sold and enter service in winter initially suffer rapid wear, followed by slower wear during the latter part of the warranty period. The opposite is true for products that are sold and enter service in summer. These seasonal variations affect the product wear rates and weighted replacement rates, which are detected early by QEWS.

Production model

The Production model identifies variations in product wear and replacement rates according to the production date of the product, not the resource in which the product is used. The production date of the product might correlate with the manufacturing equipment operator, the manufacturing process, or other important similarities.

For example, a faulty batch of products is produced during a particular period. The products are installed in resources that have different manufacturing dates. Although the resource manufacturing dates and the product production dates are unrelated, QEWS makes it easier to identify and understand the real cause of the warranty claims.

Manufacturing model

The Manufacturing model identifies variations in product wear and replacement rates according to the manufacturing date of the resource in which the product is used. The resource manufacturing date might correlate with assembly problems that occurred during a particular period.

For example, due to a short-term problem with the manufacturing process of a resource, some of the products that are used in the resource fail prematurely. Although the resource manufacturing dates and the product production dates are unrelated, QEWS makes it easier to identify and understand the real cause of the warranty claims.

You can adjust the frequency at which data is captured and input to QEWS, and the frequency at which QEWS analyses are run, according to the requirements of each situation. For example, monitoring data from a network of field service personnel might best be done on a monthly basis.

How does data flow into and out of IBM Analytics Solutions Manager on Cloud?

Data is needed by IBM Analytics Solutions Manager on Cloud in order to successfully make predictions.

Some data is provided through a compressed file called a content pack. There is a default content pack provided by IBM that contains a collection of artifacts, such as predictive models, reports, scripts, and images. You start out by importing the default content pack but later you may want to have an operations engineer customize the default content pack to better fit your environment. For more information about customizing the default content pack, see Appendix A, “The default content pack and artifacts,” on page 41.

Other data, such as historical data and real time data, must be gathered from your equipment assets and imported into Analytics Solutions Manager on Cloud.

Where does this data come from?

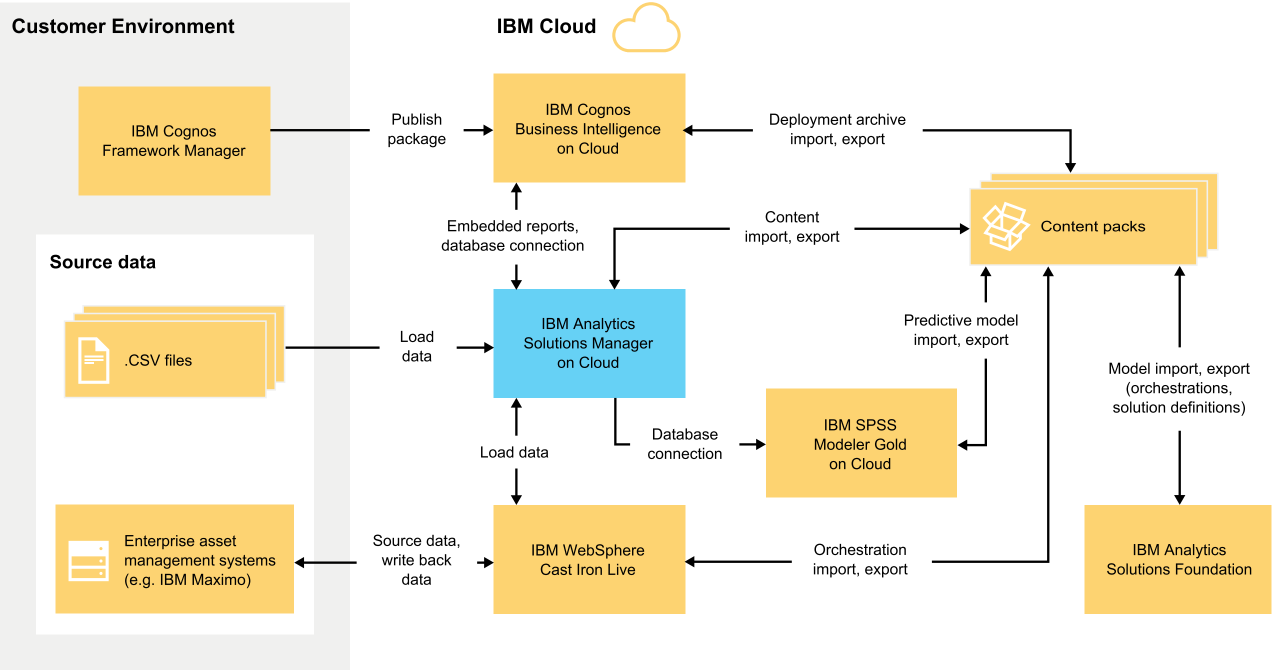

Customer Environment
IBM Cloud
IBM Cognos Framework Manager
Publish package
IBM Cognos Business Intelligence on Cloud
Deployment archive import, export
Content packs
Embedded reports, database connection
Content import, export
Source data
.CSV files
Load data
IBM Analytics Solutions Manager on Cloud
Predictive model import, export
Model import, export (orchestrations, solution definitions)
Load data
Database connection
IBM SPSS Modeler Gold on Cloud
Enterprise asset management systems (e.g. IBM Maximo)
Source data, write back data
IBM WebSphere Cast Iron Live
Orchestration import, export
IBM Analytics Solutions Foundation

Figure 1. Data flow into and out of IBM Analytics Solutions Manager on Cloud

Data from the customer environment

A data modeler can use IBM Cognos® Framework Manager to model the metadata for reports. IBM Cognos Framework Manager is a metadata modeling tool that drives query generation for IBM Cognos software. The data modeler publishes the model in a package to IBM Cognos BI on Cloud. The model can then be used to produce reports from within Analytics Solutions Manager on Cloud.

Historical data gathered from your equipment assets can be placed into .csv files and uploaded into Analytics Solutions Manager on Cloud.

IBM Maximo® can be configured to create data entries in XML format. An IBM WebSphere® Cast Iron® Live orchestration maps and transforms the Maximo data to the required logical data structure, which it sends to Analytics Solutions Manager on Cloud.

Data from the IBM cloud environment

You import the IBM default content pack when you create your first project in Analytics Solutions Manager on Cloud. The default content pack can be exported, modified, and imported back into Analytics Solutions Manager on Cloud using the following methods:

- A predictive model can be extracted from the content pack and imported into IBM SPSS® Modeler Gold where the model can be modified or extended. For example, you can run an SPSS stream and change it to use a different algorithm. To get it into the content pack, export the model and add it to the content pack.
- Orchestrations can be extracted from the content pack and imported into IBM Analytics Solutions Foundation, where calculations and aggregates can be added for predictions. For example, you can add an aggregate to include average temperature. To get the modified orchestrations into the content pack, export the orchestrations and add them to the content pack.

- A deployment archive containing reports can be extracted from the content pack and imported into IBM Cognos BI on Cloud. A report author can add a new report or modify an existing report. For example, you can add a report that shows the trend of average temperature over time for each asset. To get the new and modified reports into the content pack, export a deployment archive and add it to the content pack.

How is data backed up and restored?

IBM Predictive Solutions Foundation on Cloud uses several IBM software products and each has its own backup policy. Treat the solution content packs that you develop as code and use your source code management system to retain versions and backups.

The following table shows the backup schedule for various aspects of the solution.

Table 1. Backup schedule for solution data

Data	Backup type	Frequency	Time	Retention period
Reports	Full	Weekly	01:00 AM Eastern time on Sunday	4 weeks
	Incremental	Nightly	01:00 AM Eastern time	6 days
Models	Full	Weekly	12:01 AM Eastern time on Sunday	4 weeks
	Incremental	Nightly	12:01 AM Eastern time	6 days
Analytics Solutions Manager on Cloud loaded data	Full	Nightly		2 days
Analytics Solutions Manager on Cloud metadata and configuration data	Replication (stored in triplicate on 3 different nodes)			

During the backup window, the solution is accessible but access performance is impacted.

In the event of a system failure that causes data damage or loss, IBM will help to restore the data to the recovery time points, according to its backup policy.

Chapter 2. Set up

To begin using IBM Analytics Solutions Manager on Cloud, you create a project and import a content pack.

A *project* is a container for assets. You can place assets into a project to monitor them as a group. There are no restrictions on the type of assets that can be grouped in a project. You can create up to three projects.

A *content pack* is a compressed file that contains a collection of artifacts, such as predictive models, reports, scripts, and images.

Downloading content packs

To begin working with Analytics Solutions Manager on Cloud, you download one of the content packs that are provided by IBM. A *content pack* is a compressed file that contains a collection of artifacts, such as predictive models, reports, scripts, and images.

About this task

Download the content pack for your analysis type: Predictive Maintenance, Predictive Quality, or Predictive Warranty.

Procedure

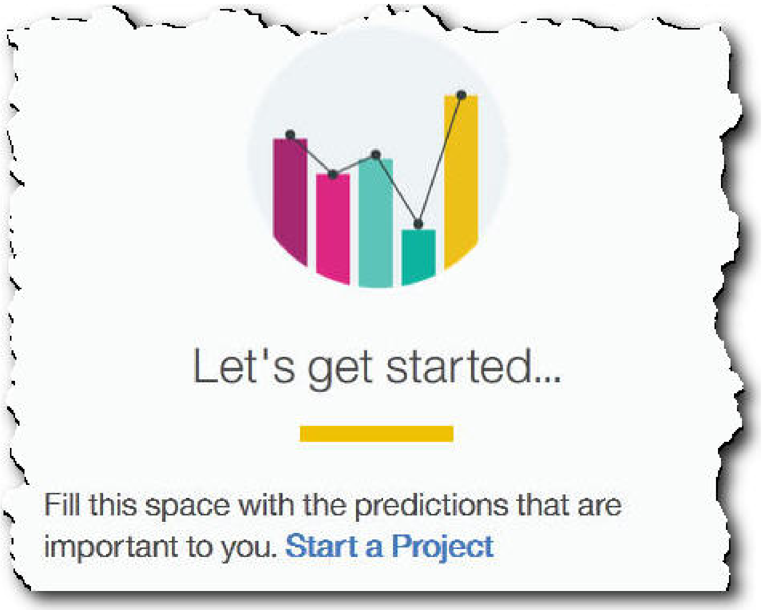
1. Click **Settings** ⚙. A dialog box is displayed.
2. Click **Download Maintenance Content Pack**, **Download Quality Content Pack**, or **Download Warranty Content Pack**. The download will take a few minutes.
3. When prompted, close the dialog box.

Creating a project

You create a project to contain your assets.

Procedure

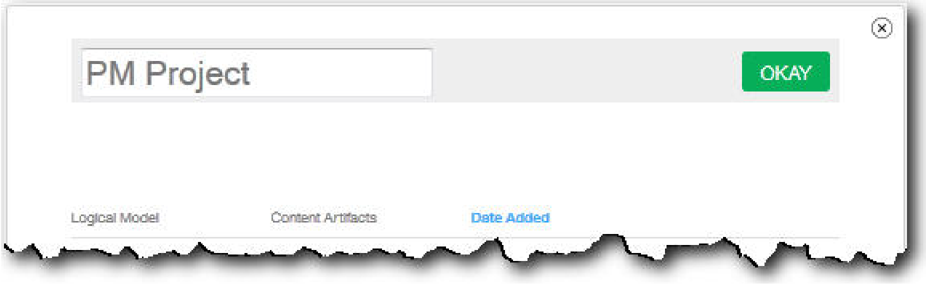
1. On the welcome page, click **Start a Project** .



Let's get started...

Fill this space with the predictions that are important to you. Start a Project

2. When the dialog box opens, enter the name of your project and click **OK**.



PM Project

Results

If you decide to exit the dialog box at this point by clicking the **Exit** icon, refresh your browser in order to see the project. When you click the project you will see a **Loading Training Data** error message because you haven't imported a content pack yet.

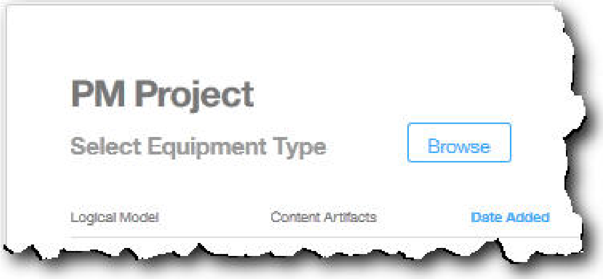
Click the **Exit** icon to close the dialog box. You can either delete the project or import a content pack into the project. For more information about importing a content pack into an existing project, see "Importing a content pack into an existing project" on page 37.

Importing a content pack

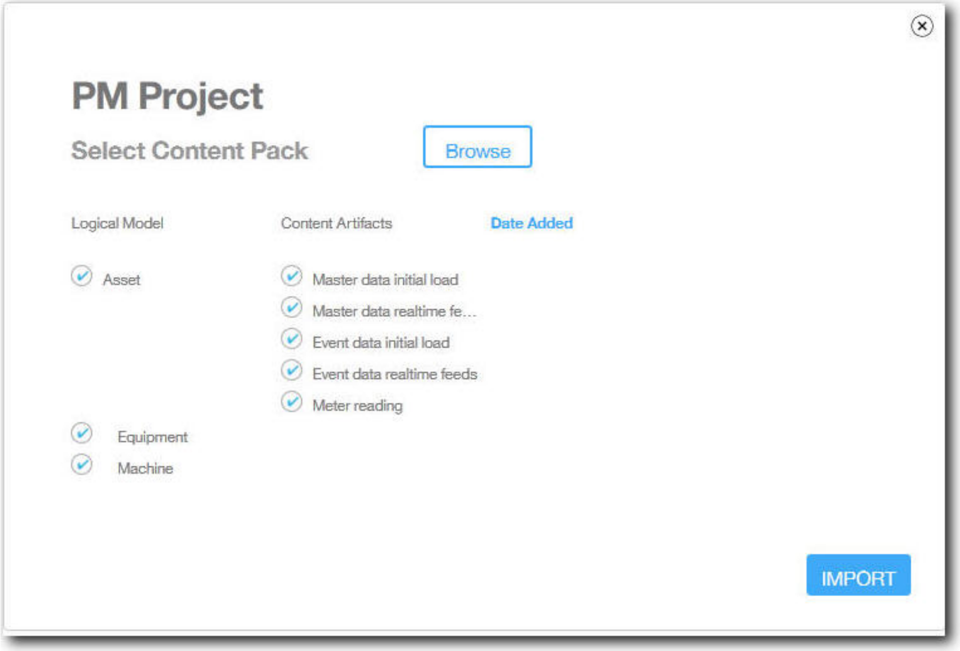
After you create a project, you import a content pack for the asset type you want to monitor. A content pack is a compressed file that contains a collection of artifacts, such as predictive models, reports, scripts, and images. A content pack is needed to predict the maintenance that is required for a particular asset type. There is a default content pack you download from the IBM site.

Procedure

1. Click **Browse**.



2. Browse to the content pack file that you downloaded.
3. Select the file and click **Open**. The hierarchy of assets shows the assets for which you have data.
4. Select the assets and reports you want to import.
5. Click **Import**.



✓ Asset
- ✓ Master data initial load
- ✓ Master data realtime fe...
- ✓ Event data initial load
- ✓ Event data realtime feeds
- ✓ Meter reading

✓ Equipment

✓ Machine

Results

When the content pack has been imported, the **Load Data** tab is displayed.

Create a sample project

IBM Predictive Solutions Foundation on Cloud includes sample data that you can use to learn about loading and analyzing data and viewing results.

Here is a checklist for creating a sample project:

__ • Download the default content pack to your computer.

For more information, see "Downloading content packs" on page 9.

__ • Open the `contentpack.zip` content pack and extract the `source_connectors\sample_datasets` folder to your computer.

__ • Create a project.

For more information, see “Creating a project” on page 9.

__ • Import the default content pack.

For more information, see “Importing a content pack” on page 10.

__ • Ensure that **Auto-Calculate** is turned off and then load initial data from the `sample_datasets` folder.

First, load the master data files (`GroupDimension.csv`, `Location.csv`, and `Machine.csv`), then load the event data files (`TrainMachineEvent_*.csv`, `TrainMaintenanceRepairEvent_*.csv`, and `TrainStoppage_*.csv`).

For more information, see “Loading initial data from files” on page 15.

__ • Analyze the data.

For more information, see “Analyzing data” on page 19.

__ • View test results.

For more information, see “Viewing test results” on page 19.

__ • Turn on **Auto-Calculate** and then load incremental data from the `sample_datasets` folder.

The incremental data files include `TestSet1MachineEvent_*.csv`, `TestSet1MaintenanceRepairEvent_*.csv`, and `TestSet1Stoppage_*.csv`. More incremental data is also available in the `TestSet2MachineEvent_*.csv`, `TestSet2MaintenanceRepairEvent_*.csv`, and `TestSet2Stoppage_*.csv` files.

For more information, see “Loading incremental data from files” on page 20.

__ • Preview reports.

For more information, see Chapter 6, “Preview reports,” on page 35.

Viewing the project activity log

The project activity log is a human-readable log of the activities that were performed on a project. Examples of project activities include uploading source data files and analyzing the data. You can review the project activity log to ensure that activities were carried out as expected, or to assist with troubleshooting problems.

Procedure

1. In an open project, click **View Project Activity Log**. A list of project activities appears.

   Tip: Click **Show Project Details** ︾ if **View Project Activity Log** is not visible.
2. If you want to save the project activity log, click **Export as CSV**. The project activity log is saved to your browser download folder as a comma-separated values (`.csv`) file.

Results

The list of project activities is sorted by date, with the most recent activities at the bottom of the list. Each activity includes the following information:

- The date and time at which the activity occurred. The time is shown in your local time zone, as determined by your browser.

  Tip: You can hover over the time to show the local time zone. The time zone is also shown in the exported project activity log file.

- The level of the message. Activities can have the following levels:
  - A green circle indicates an information message.
  - A yellow triangle indicates a warning message.
  - A red square indicates an error message.
- The type of activity. Activities can be of the following types:
  - *Scheduler* indicates a scheduled activity.
  - *Training* indicates a data analysis activity.
  - *Testing* indicates a test of the analysis.
  - *Data Load* indicates a data load activity.
  - *Import* indicates a content pack import activity.
  - *Export* indicates a content pack export activity.
- A description of the activity status, including a transaction ID. The transaction ID can be shared with IBM customer support to help identify and resolve problems.

  Tip: For *Scheduler* type activities, the transaction ID matches the ID of the scheduled item on the **Analyze Data** tab.

Chapter 3. IBM Predictive Maintenance on Cloud

After you create a Predictive Maintenance on Cloud project, you need to load initial historical data, analyze the initial data, compare predictions with actual past equipment failures, and then load incremental data to predict future maintenance requirements.

Load initial data

IBM Predictive Solutions Foundation on Cloud analyzes your initial historical data to identify patterns and make predictions based on patterns that are contained in the data. To begin, you need to load initial data to analyze. IBM Analytics Solutions Manager on Cloud shows you what data to provide. Types of data include master data and event data.

Master data includes information such as the type of equipment that is being monitored and its location.

Event data includes observation values about an event. Events can be periodic (such as manual equipment inspections) or ongoing (such as real-time device measurements).

Some data is required and other data is optional, as indicated by the data load tiles on the **Load Data** tab. The more information that you provide, typically the more accurate the predictions that are made by Analytics Solutions Manager on Cloud.

Initial data can be uploaded from comma-separated values (.csv) files, or it can be batch uploaded directly from IBM Maximo or other asset management software by using IBM WebSphere Cast Iron Live.

Loading initial data from files

You can load initial historical data into IBM Analytics Solutions Manager on Cloud by using comma-separated values (.csv) files.

Before you begin

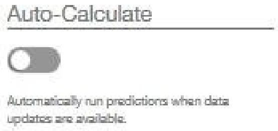
Your Information Technology department can collect historical data by querying your asset management data source. The data must be arranged according to comma-separated values (.csv) template files that are available from Analytics Solutions Manager on Cloud. To download the templates for a project, on the **Load Data** tab, hover over each data load tile and click **Download Template**.

About this task

When you load initial data, you must load master data first, followed by event data.

Procedure

1. On the **Load Data** tab, ensure that **Auto-Calculate** is turned off.

   Automatically run predictions when data updates are available.

   Important: When you load and analyze initial data, **Auto-Calculate** must be turned off.
2. Drag a comma-separated values (.csv) file onto its corresponding data load tile.

   A preview appears, showing the first 10 rows of the data that is being uploaded, for your verification.

   Tip: If the preview data is not correct, under **Current Data**, click **Clear** to erase the data from the database. Open the comma-separated values (.csv) file and verify that the information is correctly mapped to the template columns and that the data types are correct. Upload the file again.
3. To load more data, click **Back to Data Inputs** to return to the **Load Data** tab.

   When a file upload is complete, the data load tile displays a check mark and information about the most recently uploaded file.

   When a file upload is still in progress, the data load tile displays a *Processing* status. You can continue uploading files to other data load tiles, but you must wait for the upload that is in progress to finish before you upload another file to the same tile.

   Tip: Refresh your browser to check the current upload status.

Load initial data from Maximo

You can batch load initial historical data into IBM Analytics Solutions Manager on Cloud directly from IBM Maximo.

Here is a checklist for batch loading initial data from Maximo:

__ • Set up authentication between IBM Maximo, IBM WebSphere Cast Iron Live, and Analytics Solutions Manager on Cloud.

For more information about setting up authentication, see “Authentication and secure communication for Maximo integration” on page 17.

__ • Download the Cast Iron projects from Analytics Solutions Manager on Cloud.

For more information about downloading the Cast Iron projects, see “Downloading Cast Iron projects for Maximo integration” on page 18.

__ • Publish the appropriate project or projects to WebSphere Cast Iron Live:

- To extract batch master data from Maximo (*Location*, *GroupDimension*, *Asset*), use the `MaximoMasterData_Batch.par` project.
- To extract batch event data (*MaintenanceRepairEvent*) from Maximo, use the `MaximoWorkOrder_Batch.par` project.

For more information about publishing a project, see the IBM WebSphere Cast Iron documentation.

__ • Open the project in IBM WebSphere Studio Application Developer. Configure the project as required for your Maximo deployment, update the Scheduler to run the orchestration at an appropriate time, and make any other necessary customizations. Republish the project to WebSphere Cast Iron Live.

__ • Set the project configuration properties according to the specific details of your environment.

For more information about the project configuration properties, see “Properties of Cast Iron projects for Maximo integration” on page 48.

__ • Deploy and start the project configuration.

For more information about deploying project configurations, see the IBM WebSphere Cast Iron documentation.

__ • After the batch orchestration runs, undeploy the project configuration manually. Alternatively, a scheduled downtime rule can be used stop the batch orchestration.

For more information about undeploying project configurations, see the IBM WebSphere Cast Iron documentation.

Authentication and secure communication for Maximo integration

You must set up authentication to enable secure communication between IBM Maximo, IBM WebSphere Cast Iron Live, and IBM Analytics Solutions Manager on Cloud.

Authentication from Cast Iron Live to Maximo

An IBM WebSphere Cast Iron Live Secure Connector enables secure data transfer from Cast Iron Live to an IBM Maximo end point that is located behind a firewall. You must complete the following steps to enable a Secure Connector:

1. Create a Secure Connector in Cast Iron Live.
2. Download the Secure Connector configuration file and installer.
3. Install the Secure Connector in the Maximo environment, behind the firewall.
4. Configure the Secure Connector configuration file.
5. Start the Secure Connector and verify communication.

For more information about installing and configuring a Secure Connector, see the IBM Redbook titled "Getting Started with IBM WebSphere Cast Iron Cloud Integration".

After the Secure Connector is enabled, in Cast Iron Live, configure authentication credentials in the properties of the Cast Iron project to enable project orchestrations to make HTTP requests to the REST API of IBM Maximo.

Authentication from Maximo to Cast Iron Live

By default, Maximo communicates securely with Cast Iron Live by using a DigiCert Global Root CA certificate. You must complete the following steps to import the certificate to the default truststore in IBM WebSphere Application Server:

1. Log in to the IBM WebSphere Application Server Integrated Solutions Console and select **Security** > **SSL Certificate and key management** > **Key stores and certificates**.
2. Click **NodeDefaultTrustStore**.
3. Click **Signer Certificates**.
4. Click **Retrieve from port**.

5. Enter the Cast Iron Live **Host** name, **SSL Port**, and **Alias** of the web server. The Alias is *factory supplied identity*.
6. Click **Retrieve Signer Information** and then click **OK**. The root certificate is added to the list of signer certificates.
7. Restart the IBM WebSphere Application Server Integrated Solutions Console.

After the certificate is imported, use the Maximo end point definition to configure the end point and authentication credentials for accessing Cast Iron orchestrations that are exposed as REST services.

Authentication from Cast Iron Live to Analytics Solutions Manager on Cloud

To access the Analytics Solutions Manager on Cloud REST interface, in the Cast Iron projects that are used to integrate with IBM Maximo, you set the API key configurable property. The API key is supplied in the customer Welcome package.

Once the API key property is configured, Cast Iron orchestrations automatically set the key in the HTTP header.

Authentication from Analytics Solutions Manager on Cloud to Cast Iron Live

To access Cast Iron orchestrations that are exposed as REST services, in the solution configuration file (solutionconfiguration.xml), you set the Cast Iron Live credentials, end point URL, and Maximo write flag (to enable or disable writing to Maximo from Analytics Solutions Manager on Cloud).

Once the Cast Iron Live credentials, end point URL, and Maximo write flag are set, Analytics Solutions Manager on Cloud automatically sets the context variable for accessing Cast Iron Live.

Downloading Cast Iron projects for Maximo integration

From IBM Analytics Solutions Manager on Cloud, you can download IBM WebSphere Cast Iron projects (.par files) that you can use to integrate with IBM Maximo.

About this task

For more information about the Cast Iron projects, see “IBM Websphere Cast Iron Live artifacts” on page 46.

Procedure

On the **Load Data** tab, under **Connect**, click **Download All Templates**.
The `CastIron_Maximo_DataFlow.zip` file is saved to your download location. The compressed file contains the Cast Iron project files.

Test predictions

IBM Predictive Maintenance on Cloud analyzes historical data to discover patterns that are statistically significant as leading indicators of equipment failure. It uses these patterns as the basis for making predictions about the future.

The data that is used to make predictions is called the *training data*.

Sometimes patterns that are found in historical data are not likely to repeat. To avoid making predictions based on these patterns, Predictive Maintenance on Cloud sets aside data to test its ability to find patterns in unfamiliar data. This data is called the *testing data*.

Analyzing data

Start the process of analyzing historical data to discover patterns.

About this task

On the **Analyze Data** tab, you analyze historical data to discover patterns that are the basis for predictions about the future. Later, when new data is available, you can click **Retest** to validate the predictive ability against the new data.

Procedure

To run the analysis immediately, click **Run now**.

Results

It takes several minutes to several hours to analyze the data. During analysis, a progress window is displayed and the project is locked. Click **Return to All Projects** to work with your other projects. It is possible to analyze multiple projects simultaneously.

Viewing test results

The **Model Validation Report** shown on the **Test Results** tab compares predictions with actual past equipment failures for a subset of equipment that is selected and excluded from the pattern discovery process.

For each asset, the report shows the dates when:

- The actual maintenance work was done.
- The asset was not functioning.
- The asset failed.
- The failures were predicted to occur based on the data loaded.

About this task

If you want to see fewer assets or you want to see the test results for specific assets, you can filter the **Model Validation Report**.

Procedure

1. Click the **Filter By** icon Filter By .
2. Select values to filter on. If you no longer want to see the filtering values, click the **Filter By** icon to hide the filtering data.
3. If you want to see the details about a particular asset, click its equipment ID. IBM Analytics Solutions Manager on Cloud drills down to show a chart of equipment health, the details of the last maintenance that was performed, and a chart of the performance of the top six key variables.

Results

If you are not satisfied with the accuracy of the predictions that appear in the report, you can take the following actions:

- Upload more data by using the **Load Data** tab.
- Check that the equipment failures historical data is accurate. If the data is not accurate, correct and reload it using the **Load Data** tab.

Load incremental data

After IBM Analytics Solutions Manager on Cloud analyzes your initial historical data and accurately predicts maintenance events, it's time to start loading current or real-time data to feed future predictions.

Incremental data can be loaded from comma-separated values (.csv) files, or it can be loaded directly from IBM Maximo or other asset management software by using IBM WebSphere Cast Iron Live.

Loading incremental data from files

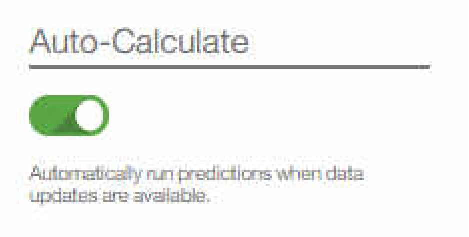
You can load incremental data into IBM Analytics Solutions Manager on Cloud by using comma-separated values (.csv) files.

Before you begin

Your Information Technology department can collect incremental data by querying your asset management data source. The data must be arranged according to comma-separated values (.csv) template files that are available from Analytics Solutions Manager on Cloud. To download the templates for a project, on the **Load Data** tab, hover over each data load tile and click **Download Template**.

Procedure

1. On the **Load Data** tab, turn on **Auto-Calculate**.



Auto-Calculate

Automatically run predictions when data updates are available.

2. Drag a comma-separated values (.csv) file onto its corresponding data load tile.

   A preview appears, showing the first 10 rows of the data that is being uploaded, for your verification.

   Tip: If the preview data is not correct, under **Current Data**, click **Clear** to erase the data from the database. Open the comma-separated values (.csv) file and verify that the information is correctly mapped to the template columns and that the data types are correct. Upload the file again.
3. To load more data, click **Back to Data Inputs** to return to the **Load Data** tab.

   When a file upload is complete, the data load tile displays a check mark and information about the most recently uploaded file.

When a file upload is still in progress, the data load tile displays a *Processing* status. You can continue uploading files to other data load tiles, but you must wait for the upload that is in progress to finish before you upload another file to the same tile.

Tip: Refresh your browser to check the current upload status.

Load incremental data from Maximo

You can load incremental real time data into IBM Analytics Solutions Manager on Cloud directly from IBM Maximo.

Here is a checklist for loading incremental data from Maximo:

__ • Set up authentication between IBM Maximo, IBM WebSphere Cast Iron Live, and Analytics Solutions Manager on Cloud.

  For more information about setting up authentication, see "Authentication and secure communication for Maximo integration" on page 17.

__ • Download the Cast Iron projects from Analytics Solutions Manager on Cloud.

  For more information about downloading the Cast Iron projects, see "Downloading Cast Iron projects for Maximo integration" on page 18.

__ • Publish the appropriate project or projects to WebSphere Cast Iron Live:
  - To extract real time master data (*Location*, *GroupDimension*, *Asset*) from Maximo, use the `MaximoMasterData_RealTime.par` project.
  - To extract real time event data (*MaintenanceRepairEvent*) from Maximo, use the `MaximoWorkOrder_RealTime.par` project.

  For more information about publishing a project, see the IBM WebSphere Cast Iron documentation.

__ • Open the project in IBM WebSphere Studio Application Developer. Configure the project as required for your Maximo deployment and make any other necessary customizations. Republish the project to WebSphere Cast Iron Live.

__ • Set the project configuration properties according to the specific details of your environment.

  For more information about the project configuration properties, see "Properties of Cast Iron projects for Maximo integration" on page 48.

__ • Deploy and start the project configuration.

  For more information about deploying project configurations, see the IBM WebSphere Cast Iron documentation.

Chapter 4. IBM Predictive Quality

After you create a Predictive Quality project, you need to load initial data, analyze the initial data to identify past quality issues, and then load incremental data to identify ongoing quality issues.

Load initial data

IBM Predictive Solutions Foundation on Cloud analyzes your initial historical data to identify quality issues. To begin, you need to load initial data to analyze. IBM Analytics Solutions Manager on Cloud shows you what data to provide. Types of data include master data and event data.

Master data includes information such as the type of equipment that is being monitored and its location.

Event data includes observation values about an event. Events can be periodic (such as manual equipment inspections) or ongoing (such as real-time device measurements).

Some data is required and other data is optional, as indicated by the data load tiles on the **Load Data** tab. The more information that you provide, typically the more accurate the predictions that are made by Analytics Solutions Manager on Cloud.

Initial data is uploaded from comma-separated values (.csv) files.

Loading initial data from files

You can load initial historical data into IBM Analytics Solutions Manager on Cloud by using comma-separated values (.csv) files.

Before you begin

Your Information Technology department can collect historical data by querying your asset management data source. The data must be arranged according to comma-separated values (.csv) template files that are available from Analytics Solutions Manager on Cloud. To download the templates for a project, on the **Load Data** tab, hover over each data load tile and click **Download Template**.

About this task

When you load initial data, you must load master data first, followed by event data.

Procedure

1. Drag a comma-separated values (.csv) file onto its corresponding data load tile.

   A preview appears, showing the first 10 rows of the data that is being uploaded, for your verification.

   Tip: If the preview data is not correct, under **Current Data**, click **Clear** to erase the data from the database. Open the comma-separated values (.csv) file and verify that the information is correctly mapped to the template columns and that the data types are correct. Upload the file again.

2. To load more data, click **Back to Data Inputs** to return to the **Load Data** tab.

   When a file upload is complete, the data load tile displays a check mark and information about the most recently uploaded file.

   When a file upload is still in progress, the data load tile displays a *Processing* status. You can continue uploading files to other data load tiles, but you must wait for the upload that is in progress to finish before you upload another file to the same tile.

   Tip: Refresh your browser to check the current upload status.

Analyzing data

Start the process of analyzing data to identify quality issues.

About this task

On the **Analyze Data** tab, you must provide values for the *PARAMETRIC_RUNDATE*, *PARAMETRIC_SUBUSECASE*, *INSPECTION_RUNDATE* and *INSPECTION_SUBUSECASE* parameters.

Table 2. Quality parameter descriptions and values

Parameter name	**Description and values**
PARAMETRIC_RUNDATE	The date up to which you want to process Parametric Quality information. The date format is yyyy-MM-dd. **Tip:** If you want to process information up to the most recent data that is available, leave the parameter blank.

Table 2. Quality parameter descriptions and values (continued)

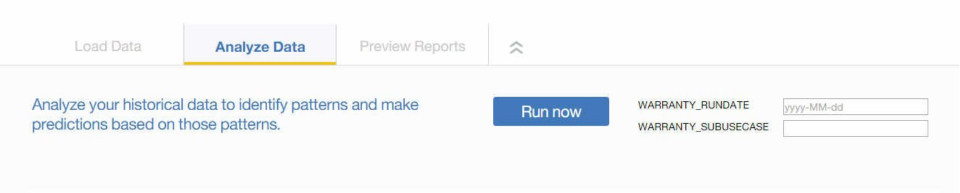
Parameter name	Description and values
PARAMETRIC_SUBUSECASE	The Parametric Quality algorithm handles various master data sets, from raw materials to manufacturing machinery to end products, and environment or location-specific data. The following categories of analysis can be used on each of the master entities. Categories of analysis can be a combination of different masters or a lone entity. **PRVariableEvent** *Process Resource Validation* is the default Parametric use case, in which the process, and the resource that takes part in process, are monitored based on a defined set of measurement types (variables). These variables are compared against target values, acceptable limits, unacceptable limits, standard deviation, false alarm rates, and unacceptable factors. **RVariableEvent** In the *Resource Validation* use case, a resource is monitored based on the standard operation limits across several measurement types (variables). This kind of health check is essential in identifying issues in the resource and to remediate to improve performance and throughput. **PBVariableEvent** In the *Product Validation* use case, given a set of variables whose targets are set for the product to meet, any deviation or drift beyond the allowed deviation highlights flaws in the product. **MVariableEvent** In the *Material Validation* use case, raw materials that are purchased from a vendor are monitored for a defined set of guidelines and are validated to check the quality of the procured material. **LVariableEvent** In the *Location Conduceability* use case, a location can be analyzed for its suitability to a particular operation. Variables like pressure, temperature, humidity, and their time slide values are considered.
INSPECTION_RUNDATE	The date up to which you want to process Inspection Quality information. The date format is yyyy-MM-dd. **Tip:** If you want to process information up to the most recent data that is available, leave the parameter blank.

Table 2. Quality parameter descriptions and values (continued)

Parameter name	Description and values
INSPECTION_SUBUSECASE	The Inspection Quality algorithm can be carried out on a product or a raw material. **ProductInspectionEvent** In the *Product Inspection* use case, the inspection or attribute analysis is carried out on a specific product, given input data about the ratio of failed to tested products. **MaterialInspectionEvent** The *Material Inspection* use case focuses on the raw material that is procured from a vendor, given input data about the ratio of failed to tested raw materials.

Procedure

1. On the **Analyze Data** tab, enter the required parameter values.



Analyze your historical data to identify patterns and make predictions based on those patterns.

WARRANTY_RUNDATE yyyy-MM-dd

WARRANTY_SUBUSECASE

2. To run the analysis immediately, click **Run now**.

Results

It takes several minutes to several hours to analyze the data. During analysis, a progress window is displayed and the project is locked. Click **Return to All Projects** to work with your other projects. It is possible to analyze multiple projects simultaneously.

Load incremental data

After IBM Analytics Solutions Manager on Cloud analyzes your initial historical data, it's time to start loading current or real-time data to identify ongoing quality issues.

Incremental data is loaded from comma-separated values (.csv) files.

Loading incremental data from files

You can load incremental data into IBM Analytics Solutions Manager on Cloud by using comma-separated values (.csv) files.

Before you begin

Your Information Technology department can collect incremental data by querying your asset management data source. The data must be arranged according to comma-separated values (.csv) template files that are available from Analytics Solutions Manager on Cloud. To download the templates for a project, on the **Load Data** tab, hover over each data load tile and click **Download Template**.

Procedure

1. Drag a comma-separated values (.csv) file onto its corresponding data load tile.

   A preview appears, showing the first 10 rows of the data that is being uploaded, for your verification.

   Tip: If the preview data is not correct, under **Current Data**, click **Clear** to erase the data from the database. Open the comma-separated values (.csv) file and verify that the information is correctly mapped to the template columns and that the data types are correct. Upload the file again.
2. To load more data, click **Back to Data Inputs** to return to the **Load Data** tab.

   When a file upload is complete, the data load tile displays a check mark and information about the most recently uploaded file.

   When a file upload is still in progress, the data load tile displays a *Processing* status. You can continue uploading files to other data load tiles, but you must wait for the upload that is in progress to finish before you upload another file to the same tile.

   Tip: Refresh your browser to check the current upload status.

Chapter 5. IBM Predictive Warranty

After you create a Predictive Warranty project, you need to load initial data, analyze the initial data to identify past warranty issues, and then load incremental data to identify ongoing warranty issues.

Load initial data

IBM Predictive Solutions Foundation on Cloud analyzes your initial historical data to identify warranty issues. To begin, you need to load initial data to analyze. IBM Analytics Solutions Manager on Cloud shows you what data to provide. Types of data include master data and event data.

Master data includes information such as the type of equipment that is being monitored and its location.

Event data includes observation values about an event. Events can be periodic (such as manual equipment inspections) or ongoing (such as real-time device measurements).

Some data is required and other data is optional, as indicated by the data load tiles on the **Load Data** tab. The more information that you provide, typically the more accurate the predictions that are made by Analytics Solutions Manager on Cloud.

Initial data is uploaded from comma-separated values (.csv) files.

Loading initial data from files

You can load initial historical data into IBM Analytics Solutions Manager on Cloud by using comma-separated values (.csv) files.

Before you begin

Your Information Technology department can collect historical data by querying your asset management data source. The data must be arranged according to comma-separated values (.csv) template files that are available from Analytics Solutions Manager on Cloud. To download the templates for a project, on the **Load Data** tab, hover over each data load tile and click **Download Template**.

About this task

When you load initial data, you must load master data first, followed by event data.

Procedure

1. Drag a comma-separated values (.csv) file onto its corresponding data load tile.

   A preview appears, showing the first 10 rows of the data that is being uploaded, for your verification.

   Tip: If the preview data is not correct, under **Current Data**, click **Clear** to erase the data from the database. Open the comma-separated values (.csv) file and verify that the information is correctly mapped to the template columns and that the data types are correct. Upload the file again.

2. To load more data, click **Back to Data Inputs** to return to the **Load Data** tab.

   When a file upload is complete, the data load tile displays a check mark and information about the most recently uploaded file.

   When a file upload is still in progress, the data load tile displays a *Processing* status. You can continue uploading files to other data load tiles, but you must wait for the upload that is in progress to finish before you upload another file to the same tile.

   Tip: Refresh your browser to check the current upload status.

Analyzing data

Start the process of analyzing data to identify warranty issues.

About this task

On the **Analyze Data** tab, you must provide values for the *WARRANTY_RUNDATE* and *WARRANTY_SUBUSECASE* parameters.

Table 3. Warranty parameter descriptions and values

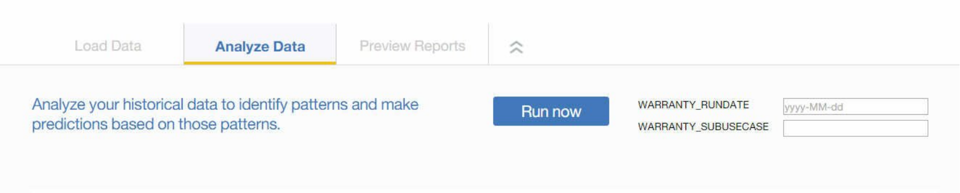
Parameter name	Description and values
WARRANTY_RUNDATE	The date up to which you want to process Warranty information. The date format is yyyy-MM-dd. **Tip:** If you want to process information up to the most recent data that is available, leave the parameter blank.

Table 3. Warranty parameter descriptions and values (continued)

Parameter name	Description and values
WARRANTY_SUBUSECASE	**SALES** The *Sales* model identifies variations in product wear and replacement rates according to the date of sale. The date of sale might correlate with in-service conditions, seasonal climatic conditions, a particular customer, or other important similarities. For example, a product carries a one-year warranty. In cold conditions, the product becomes brittle and wears prematurely. In certain geographies, products that are sold and enter service in winter initially suffer rapid wear, followed by slower wear during the latter part of the warranty period. The opposite is true for products that are sold and enter service in summer. These seasonal variations affect the product wear rates and weighted replacement rates, which are detected early by QEWS. **PROD** The *Production* model identifies variations in product wear and replacement rates according to the production date of the product, not the resource in which the product is used. The production date of the product might correlate with the manufacturing equipment operator, the manufacturing process, or other important similarities. For example, a faulty batch of products is produced during a particular period. The products are installed in resources that have different manufacturing dates. Although the resource manufacturing dates and the product production dates are unrelated, QEWS makes it easier to identify and understand the real cause of the warranty claims. **MFG** The *Manufacturing* model identifies variations in product wear and replacement rates according to the manufacturing date of the resource in which the product is used. The resource manufacturing date might correlate with assembly problems that occurred during a particular period. For example, due to a short-term problem with the manufacturing process of a resource, some of the products that are used in the resource fail prematurely. Although the resource manufacturing dates and the product production dates are unrelated, QEWS makes it easier to identify and understand the real cause of the warranty claims.

Procedure

1. On the **Analyze Data** tab, enter the required parameter values.



Analyze your historical data to identify patterns and make predictions based on those patterns.

2. To run the analysis immediately, click **Run now**.

Results

It takes several minutes to several hours to analyze the data. During analysis, a progress window is displayed and the project is locked. Click **Return to All Projects** to work with your other projects. It is possible to analyze multiple projects simultaneously.

Load incremental data

After IBM Analytics Solutions Manager on Cloud analyzes your initial historical data, it's time to start loading current or real-time data to identify ongoing warranty issues.

Incremental data is loaded from comma-separated values (.csv) files.

Loading incremental data from files

You can load incremental data into IBM Analytics Solutions Manager on Cloud by using comma-separated values (.csv) files.

Before you begin

Your Information Technology department can collect incremental data by querying your asset management data source. The data must be arranged according to comma-separated values (.csv) template files that are available from Analytics Solutions Manager on Cloud. To download the templates for a project, on the **Load Data** tab, hover over each data load tile and click **Download Template**.

Procedure

1. Drag a comma-separated values (.csv) file onto its corresponding data load tile.

   A preview appears, showing the first 10 rows of the data that is being uploaded, for your verification.

   Tip: If the preview data is not correct, under **Current Data**, click **Clear** to erase the data from the database. Open the comma-separated values (.csv) file and verify that the information is correctly mapped to the template columns and that the data types are correct. Upload the file again.
2. To load more data, click **Back to Data Inputs** to return to the **Load Data** tab.

   When a file upload is complete, the data load tile displays a check mark and information about the most recently uploaded file.

When a file upload is still in progress, the data load tile displays a *Processing* status. You can continue uploading files to other data load tiles, but you must wait for the upload that is in progress to finish before you upload another file to the same tile.

Tip: Refresh your browser to check the current upload status.

Chapter 6. Preview reports

IBM Predictive Solutions Foundation on Cloud includes reports and dashboards that you can use to monitor the health status of your equipment assets.

Setting up reports

The project reports are displayed in IBM Cognos Connection. Cognos Connection is the Web portal for IBM Cognos Business Intelligence. Use the portal to publish, find, manage, organize, and view your project reports.

Procedure

1. Click the **Preview Reports** tab.

   The available project reports are displayed in Cognos Connection.
2. View, run, modify, schedule, or set report properties as required.

   For more information about Cognos Connection, see the *IBM Cognos Connection User Guide*.

Viewing reports

The IBM Predictive Solutions Foundation on Cloud report dashboard displays reports that you can use to monitor the health status of your equipment assets.

Procedure

1. Click the **Reports** icon to open the report dashboard view.
2. Modify the dashboard as required by resizing, adding, or removing report objects.

Chapter 7. Export and import content packs

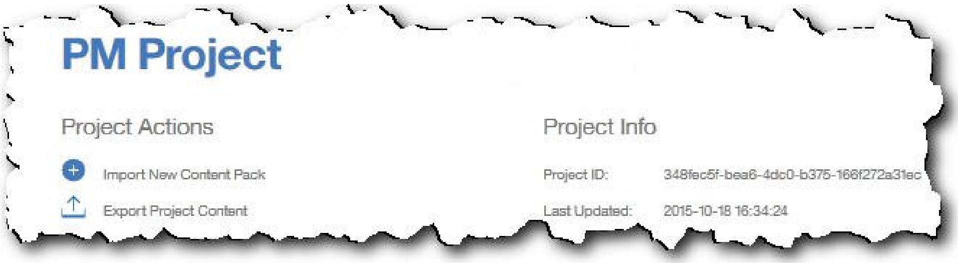
You can import a content pack into an existing project and you can export a content pack.

Exporting a content pack

You can export a content pack if you want to modify it.

Procedure

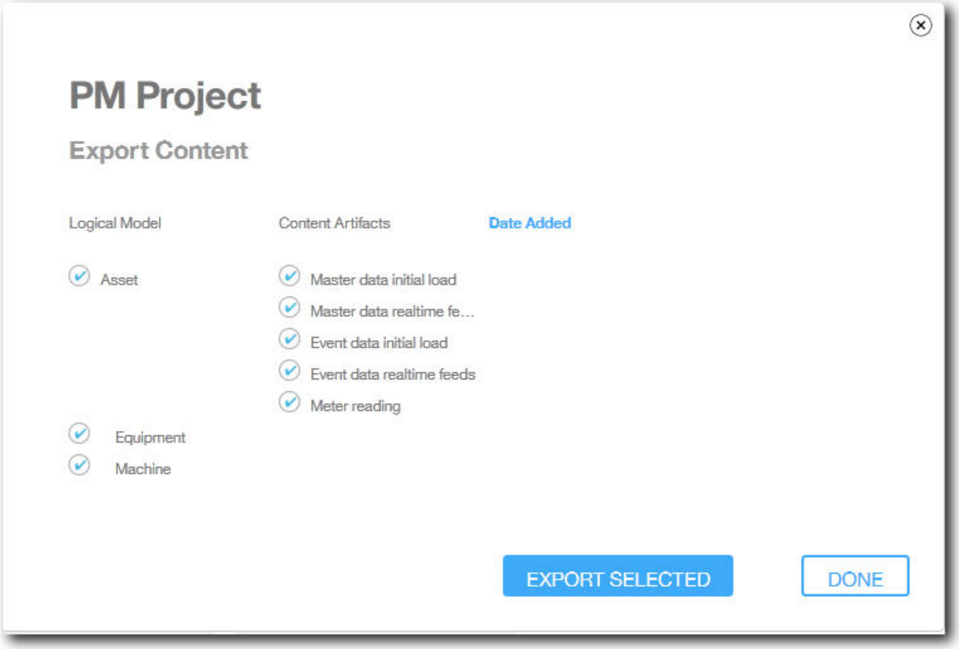
1. If you have your project selected, you should see the **Projects Actions** menu.



Project ID: 348fec5f-bea6-4dc0-b375-166f272a31ec

Last Updated: 2015-10-18 16:34:24

2. Click **Export Project Content**. The hierarchy of assets shows the assets for which you have data.
3. Select the assets and reports you want to export.
4. Click **Export Selected**.



✓ Asset

✓ Master data initial load
✓ Master data realtime fe…
✓ Event data initial load
✓ Event data realtime feeds
✓ Meter reading

✓ Equipment
✓ Machine

5. When the content pack has been downloaded, click **Done**.

Importing a content pack into an existing project

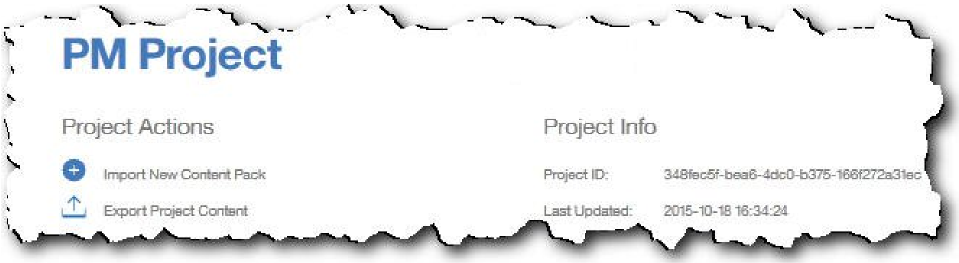
You can import a content pack into an existing project.

About this task

If you have created a project but have not imported a content pack into that project, you can import a content pack using the following steps.

Procedure

1. If you have your project selected, you should see the **Projects Actions** menu.



PM Project

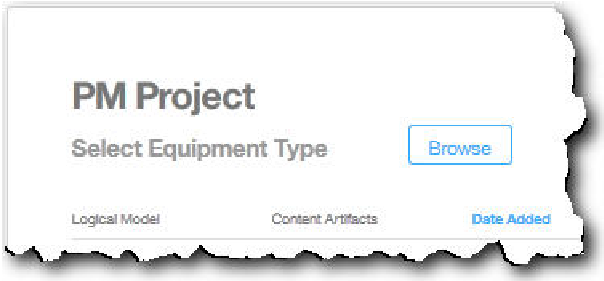
Project Actions

Project Info

Project ID: 348fec5f-bea6-4dc0-b375-166f272a31ec

Last Updated: 2015-10-18 16:34:24

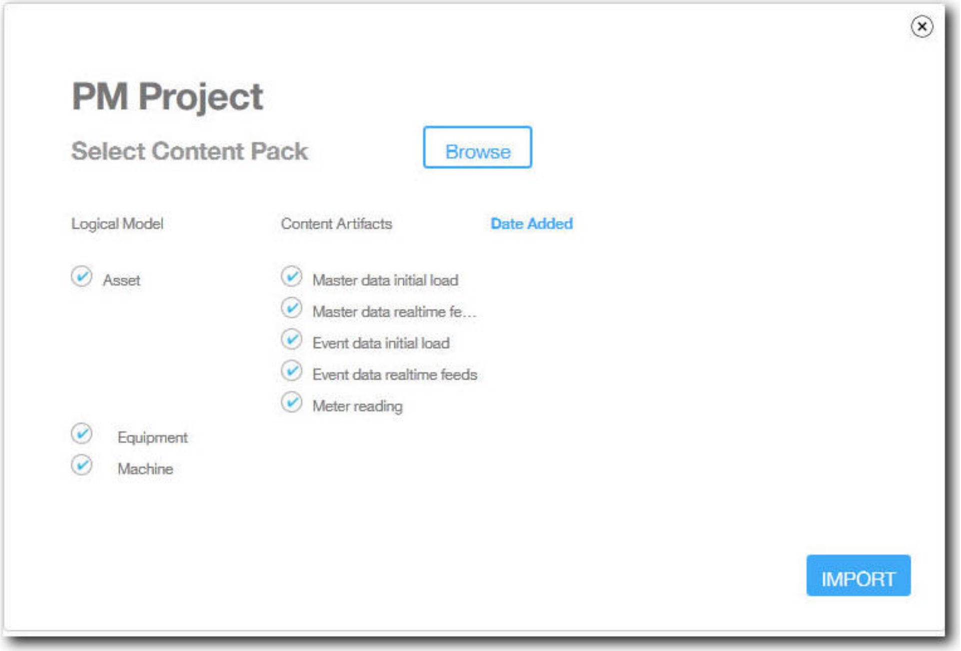
2. Click **Import New Content Pack**.
3. Click **Browse**.



PM Project

Select Equipment Type

4. Browse to the content pack file that you downloaded.
5. Select the file and click **Open**. The hierarchy of assets shows the assets for which you have data.
6. Select the assets and reports you want to import.
7. Click **Import**.



PM Project

Select Content Pack

Logical Model	Content Artifacts	Date Added
✓ Asset	✓ Master data initial load	
	✓ Master data realtime fe…	
	✓ Event data initial load	
	✓ Event data realtime feeds	
	✓ Meter reading	
✓ Equipment		
✓ Machine		

Results

When the content pack has been imported, the **Load Data** tab is displayed.

Appendix A. The default content pack and artifacts

There is a default content pack provided by IBM that contains a collection of artifacts, such as predictive models, reports, scripts, and images. A content author can modify this content pack to meet business needs.

At the root of the content pack, there is a file named `solutionconfiguration.xml`. For each level of the logical model hierarchy, you can define associations to content artifacts to load data, run predictions, and visualize results. This file contains a catalog of all artifacts in your solution. For each content artifact, there is a version number and a name, and what categories it belongs to. For example:

```
<predictiveModel version="1.0" name="text" path="predictive/DB_FBA_DATA_PREP.str"
 isFeature="text" id="DB_FBA_DATA_PREP" author="IBM"/>
<predictiveModel version="1.0" name="text" path="predictive/DB_FBA_SCORING_EVENT.str"
 isFeature="text" id="DB_FBA_SCORING_EVENT" author="IBM"/>
<predictiveModel version="1.0" name="text" path="predictive/DB_FBA_TEST_RESULTS.str"
 isFeature="text" id="DB_FBA_TEST_RESULTS" author="IBM"/>
```

When you customize by adding a new artifact, you need to add a line like this:

```
<predictiveModel version="1.0" name="text" path="predictive/my_model.str"
 isFeature="text" id="my_model" author="My Name"/>
```

If you change it, increment the version number.

```
<predictiveModel version="1.1" name="text" path="predictive/DB_FBA_TEST_RESULTS.str"
 isFeature="text" id="DB_FBA_TEST_RESULTS" author="IBM"/>
```

To delete, remove a line.

Data model

The data model file name is `pmq_bluemix.sql`. It is in the `database_scripts` folder in the content pack.

This SQL file contains instructions to create all tables such as master, event and profile tables for IBM Predictive Maintenance on Cloud. It also contains a stored procedure to initialize the Calendar data for the solution and populate a default language and tenant for the solution.

A content author can provide other SQL files to define a physical data store.

IBM Analytics Solutions Foundation artifacts

IBM Analytic Solutions Foundation is an application that enables you to define and manage aggregates and build the orchestration process to feed that aggregated data into predictive models. Solutions created with IBM Analytics Solutions Foundation consume events and make recommendations. They use profiles and key performance indicators to aggregate the events. These aggregations are used to provide scores using predictive models. Decision management makes recommendations based on the values of the scores.

A content author can provide a physical model, logical model and orchestration in the pmq_models folder.

Logical model

The logical model file `SolutionLogicalModel.XML` is found in the `pmq_models\logical_definition` folder.

A logical model is used to define a logical view of the physical data model. Depending on the business case, an author can define one or many logical models. A content author can define relationships between entities. For example, an author can define hierarchical relationships for various types of equipment such as the following hierarchy:

```
Equipment
    Electrical equipment
        Transformer
            Distribution Transformer
```

The following is a metadata representation of the logical model shows how the hierarchy is defined within the logical model. For example, resource is a parent and asset is a child. It also captures asset attributes and their properties such as display name and data type.

```
<entitySubType code="Asset" description="A resource of type asset"
displayName="Asset" extends="Resource" id="" version="1.0" author="IBM" >
    <attribute code="installationDate" displayName="Installation Date"
 dataType="timestamp" description="Installation Date" isRequired="true"/>
    <attribute code="CriticalValue" displayName="Critical Value"
 dataType="double" description="Critical Value of an asset" isRequired="false"/>
    <attributeAlias code="SerialNumber" description="Serial Number of the Asset"
 displayName="Asset Serial Number" attributeRef="ResourceCd1" />
    <attributeAlias code="Model" description="Model of the Asset"
 displayName="Asset Model" attributeRef="ResourceCd2" />
    <attributeAlias code="AssetName" description="Name of the Asset"
 displayName="Asset Name" attributeRef="ResourceName"/>
    <attributeAlias code="AssetLocation" description="Location of the Asset"
 displayName="Asset Location" attributeRef="ResourceLocation"/>
    <attributeAlias code="ParentSerialNumber"
 displayName="Parent Asset Serial Number"
 description="Serial Number of the parent asset" attributeRef="ParentResourceCd1" />
    <attributeAlias code="ParentModel"
 displayName="Parent Asset Model"
 description="Model of the parent asset" attributeRef="ParentResourceCd2" />
</entitySubType>
```

```
  <entitySubType code="Equipment" displayName="Equipment"
 description="An asset of type equipment" extends="Asset" id=""
 version="1.0" author="IBM" >
  </entitySubType>
```

```
<entitySubType code="Machine" displayName="Machine"
 description="Sample Machine" extends="Asset" id="" version="1.0" author="IBM" >
    <attribute code="LoadRating" displayName="Load Rating"
 dataType="double" description="Load Rating" isRequired="false"/>
    <attribute code="MTBF" displayName="Mean Time Between Failures"
 dataType="double" description="Mean Time Between Failures" isRequired="false"/>
  </entitySubType>
```

Similarly a content author can define various events and event subtypes. This logical model contains the definition for a maintenance event that contains details about its attributes and event sub types depending on type of equipment. For example a Machine provides various reading such as “Temperature”, “Ambient Temperature” and so on. The event sub type definition for Machine can be defined as follows:

```
<eventSubType code="MachineEvent" description="Represents a Machine Event"
 displayName="Machine Event" extends="MaintenanceEvent" id="" version="1.0" author="IBM" >
    <typePropertyValue propertyRef="ResourceType" value="Machine" />
```

```
<attribute code="Temperature" displayName="Temperature"
dataType="double" description="Temperature"/>
<attribute code="AmbientTemperature" displayName="Ambient Temperature"
dataType="double" description="Ambient Temperature"/>
<attribute code="Load" displayName="Load"
dataType="double" description="Load"/>
<attribute code="Vibration" displayName="Vibration"
dataType="double" description="Vibration"/>
<attribute code="Exception" displayName="Exception"
dataType="double" description="Exception"/>
<attribute code="Overload" displayName="Overload"
dataType="double" description="Overload"/>
<attribute code="CumulativeLoad" displayName="Cumulative Load"
dataType="double" description="Cumulative Load"/>
<attribute code="CumulativeOverload" displayName="Cumulative Overload"
dataType="double" description="Cumulative Overload"/>
<attribute code="TemperatureRatio" displayName="Temperature Ratio"
dataType="double" description="Temperature Ratio"/>
<attribute code="CumulativeStoppage" displayName="Cumulative Stoppage"
dataType="double" description="Cumulative Stoppage"/>
</eventSubType>
```

Solution definition

The solution definition file `PMQ_solution_definition.xml` is found in the `pmq_models\solution_definition` folder. This solution configuration contains definition for master tables, event tables and profile tables. It also contains definition for services, calculation referred during orchestration.

A content author can provide solution configuration XML files in this folder. A solution configuration XML file is used to define the structure of a physical data model, various service definition, and calculation definition that are referred during orchestrations. For any solution, there is only one solution definition.

Orchestration definitions

The orchestration definition files are found in the `pmq_models\orchestration_definition` folder. A content author can add orchestrations to this folder. For example, a content author can add an orchestration to process raw data and generate aggregate data, to invoke the predictive model, or to process model scoring results.

The orchestrations provided with the default content pack are described in the following table:

Table 4. Orchestration definitions

Orchestration definition file name	Description
PMQ_orchestration_definition_FAS.xml	Contains rules to use when events such as FailureEvent, StoppageEvent and AlertEvent are reported.
PMQ_orchestration_definition_job.xml	Contains rules to use when a user clicks **Go** on the **Analyze Data** tab.
PMQ_orchestration_definition_jobscore.xml	Not used at this time.
PMQ_orchestration_definition_jobtest.xml	Contains rules to use when user click **Retest** on the **Test Results** tab.

Table 4. Orchestration definitions (continued)

Orchestration definition file name	Description
PMQ_orchestration_definition_maintenance.xml	Contains rules to use when a user sends maintenance data.
PMQ_orchestration_definition_poc.xml	Contains sample orchestrations that a content author can use as examples when creating their own orchestrations.
PMQ_orchestration_definition_recommended.xml	Contains orchestrations executed when predictive model output results are processed.
PMQ_orchestration_definition_recommended.xml	Contains rules to be used for the sample Machine.
PMQ_orchestration_definition_sample_recommended.xml	Contains rules that specify how sample predictive models results are processed.
PMQ_orchestration_definition_topn.xml	Contains rules that specify how TopN model output results are processed.

IBM SPSS artifacts

IBM SPSS Modeler Gold on Cloud is a set of data mining tools that enable you to create predictive models for analyzing historical patterns and predicting future outcomes. IBM SPSS predictive models are provided as artifacts in the `predictive` folder. A content author can use IBM SPSS Modeler Gold on Cloud to develop new predictive models that meet their business needs and add them to this folder.

Maintenance Streams

Maintenance artifacts in the predictive folder are as follows:

Table 5. Maintenance Streams in predictive folder

Modeler Streams	Description
DB_FBA_DATA_PREP.str	Used for data preparation.
DB_FBA_SCORING_EVENT.str	Used for generating an event structure.
DB_FBA_TEST_RESULTS.str	Used for generating test results.
DB_MAINTENANCE_CRT_TABLE.str	Used for Maintenance Analytics.
DB_MAINTENANCE_DATA_PREP.str	Used for data preparation.
DB_MAINTENANCE_EVENTS.str	Used for generating an event structure for Maintenance Analytics.
DB_MAINTENANCE_MODEL.str	Used for the Maintenance Analytics model.
DB_TOPN.str	Used for TopN model.

The `predictive\failure` folder contains SPSS streams for when the model is FAILURE. It contains streams for both the Featured Based Analytics and the Integration Analytics models. The streams are DB_FBA_DTE_FAILURE.str, DB_FBA_HSE_FAILURE.str, DB_INT_HSE_FAILURE, and DB_INT_DTE_FAILURE.str.

The `predictive\stoppage` folder contains SPSS streams for when the model is STOPPAGE. It contains streams for both the Featured Based Analytics and the Integration Analytics models. The streams are DB_FBA_DTE_ STOPPAGE.str, DB_FBA_HSE_ STOPPAGE.str, DB_INT_HSE_STOPPAGE, and DB_INT_DTE_ STOPPAGE.str.

The `predictive\maintenance` folder contains SPSS streams for when the model is MAINTENANCE. It contains streams for both the Featured Based Analytics and the Integration Analytics models. The streams are DB_FBA_DTE_ MAINTENANCE.str, DB_FBA_HSE_ MAINTENANCE.str, DB_INT_HSE_ MAINTENANCE, and DB_INT_DTE_ MAINTENANCE.str.

IBM Cognos Business Intelligence artifacts

IBM Cognos Business Intelligence on Cloud is a suite that provides tools to create reports and dashboards and build interactive analyses. A content author can develop new BI views and add them to the deployment archive provided in the default content pack.

The IBM Cognos Business Intelligence artifacts are contained within the `reporting` folder. The folder contains the following zip files:

- IBMPMQ(DQM) Model.zip is the Cognos Framework Manger model.
- IBMPMQ(DQM).zip is the Cognos package that contains reports, dashboards, and visualizations.
- Images.zip contains images used in reports and dashboards.

Contents of the IBM Cognos package

The IBM Cognos package contains the following:

Table 6. Package artifacts

File name	Description
Maintenance View Dashboard	Provides information on actual failure or stoppage events of the machine. There are various profiles shown on the chart that are single day event and predicted date range event information. The Summary List report shows the health of the asset, the count of various events that were reported for the asset during the selected date range (for example, the number of failures), and the maintenance activities that were performed on the asset during the selected date range.
Summary View Dashboard	Shows the state of the machine based on its average health score, the overall health of the machine since it was commissioned, and the top six predictors that contributed to the current state of the machine. The summary provides details of each machine for the selected date range.
Summary View Dashboard_Workspace	Provides users with the flexibility to add and remove widgets.

Table 6. Package artifacts (continued)

File name	Description
Drill Through Reports folder	Contains the following reports that are triggered from the drill though links provided in the parent reports and dashboards. These reports are not to be executed directly. • Reusable Object Library: This for designing the header and footer in all reports. It is used as a layout reference object in the header and footer section of all reports and dashboards. • Health Score and Probability Report and Top Factors Report: Provides information on individual asset or machine. It renders Top six profile influence of a resource, last day health score, last maintenance activity performed on machine, location of resource. They are linked as drill through targets from the Maintenance View and Summary View dashboards. • Summary View Dashboard_Workspace_HealthScoreAverage and Summary View dashboard_Workspace_Prompts: Used as widgets in Summary View Dashboard_Workspace. • viz Bundles: Used in the reports and dashboards, they include vis.ibm.com.Gantt4Top6, vis.ibm.com.GanttChartResourceHealth, vis.ibm.com.GanttChartwithDateNow, vis.ibm.com.HealthScoreChart, vis.ibm.com.HealthScoreOverTimeChart, vis.ibm.com.lineEquipmentHealth_NoData, vis.ibm.com.LineThreshold

IBM Websphere Cast Iron Live artifacts

IBM WebSphere Cast Iron Live is a cloud-based platform for bringing on-premises data into the cloud. It enables you to load batch historical data and subscribe to real time data feeds. IBM Predictive Solutions Foundation on Cloud provides IBM Websphere Cast Iron Live sample orchestrations to support Maximo integration for getting master and event data from IBM Maximo and to feed score results as a meter reading to IBM Maximo. These orchestrations are provided as artifacts in the `source_connectors\cast_iron` folder of the default content pack.

The following project files are Cast Iron templates for Maximo integration. Each project contains one or more orchestrations.

Master data

Master data templates for gathering batch and real time data are shown in the following table:

Table 7. Master data

Project file	Description
MaximoMasterData_Batch.par	Use this template to pull master data in a batch from Maximo. Cast Iron Sample Name: MaximoMasterData_Batch Contains three orchestrations: • GetMaximoClassification to process group dimension master data • GetMaximoLocation to process location master data • GetMaximoAsset to process resource master data
MaximoMasterData_RealTime.par	Use this template to push master data in real time from Maximo. Cast Iron Sample Name: MaximoMasterData_RealTime Contains three orchestrations: • ReceiveMaximoClassificationto process group dimension master data • ReceiveMaximoLocation to process location master data • ReceiveMaximoAsset to process resource master data

Event data

Event data templates for gathering batch and real time data are shown in the following table:

Table 8. Event data

Project file	Description
MaximoWorkOrder_Batch.par	Use this template to pull maintenance event data in a batch from Maximo. Cast Iron Sample Name: MaximoWorkOrder_Batch Contains three orchestrations: • GetMaximoWorkOrder_AM –To process Actual Maintenance event • GetMaximoWorkOrder_SM – To process Scheduled Maintenance events • GetMaximoWorkOrder_BRK - To process Fail events

Table 8. Event data (continued)

Project file	Description
MaximoWorkOrder_RealTime.par	Use this template to pull maintenance event data in a batch from Maximo. Cast Iron Sample Name: MaximoWorkOrder_RealTime Contains an orchestration named ReceiveMaximoWorkOrder used to process Actual Maintenance, Scheduled Maintenance and Fail events.

Scoring result data

Use this template to feed scoring results as a meter reading. The project file MaximoMeterReading.par contains a single orchestration named MaximoMeterReading to process a predicted score result from IBM Predictive Solutions Foundation on Cloud and feed it as meter reading into Maximo.

Properties of Cast Iron projects for Maximo integration

IBM Predictive Solutions Foundation on Cloud includes IBM WebSphere Cast Iron projects (.par files) that you can use to integrate with IBM Maximo. There are projects for loading master data in batch mode, master data in real time, event data in batch mode, and event data in real time. There is also a project for pushing equipment health scores and predictions from Predictive Solutions Foundation on Cloud to Maximo. Each project has properties that you must configure.

For more information about the Cast Iron projects, see "IBM Websphere Cast Iron Live artifacts" on page 46.

Properties of the MaximoMasterData_Batch.par project

The project contains the following properties:

Table 9. MaximoMasterData_Batch.par properties

Property name	Description
MaximoUser	The Maximo user name, which is used for authentication to make an HTTP GET request to Maximo.
MaximoPassword	The Maximo password, which is used for authentication to make an HTTP GET request to Maximo.
MaximoHostName	The Maximo hostname/IP, which is used to make an HTTP GET request to Maximo.
MaximoPort	The Maximo port, which is used to make an HTTP GET request to Maximo.
MaximoSecureConnector	The name of the secure connector that is configured to enable communication from Cast Iron Live to Maximo.
GetAsset_URL	The Maximo URL that is used to GET (pull) asset/resource data.

Table 9. MaximoMasterData_Batch.par properties (continued)

Property name	Description
GetClassification_URL	The Maximo URL that is used to GET (pull) classification/groupdim data.
GetLocation_URL	The Maximo URL that is used to GET (pull) serviceaddress/location data.
SolutionManagerApiKey	The IBM Analytics Solutions Manager on Cloud API key, which is used for authentication to make an HTTP POST request to Analytics Solutions Manager on Cloud. The API key is supplied in the customer Welcome package.
SolutionManagerHostName	The Analytics Solutions Manager on Cloud hostname/IP, which is used to make an HTTP POST request to the REST API of Analytics Solutions Manager on Cloud.
SolutionManagerPort	The Analytics Solutions Manager on Cloud port, which is used to make an HTTP POST request to the REST API of Analytics Solutions Manager on Cloud.
PostAsset_URL	The Analytics Solutions Manager on Cloud URL that is used to POST (push) asset/resource data. In the URL, replace `<project_id>` with the actual project ID.
PostGroupDim_URL	The Analytics Solutions Manager on Cloud URL that is used to POST (push) group dimension data. In the URL, replace `<project_id>` with the actual project ID.
PostLocation_URL	The Analytics Solutions Manager on Cloud URL that is used to POST (push) location data. In the URL, replace `<project_id>` with the actual project ID.

Properties of the MaximoMasterData_RealTime.par project

The project contains the following properties:

Table 10. MaximoMasterData_RealTime.par properties

Property name	Description
ReceiveAsset_URL	The IBM WebSphere Cast Iron Live URL that is used to receive asset data from Maximo.
ReceiveClassification_URL	The Cast Iron Live URL that is used to receive classification data from Maximo.
ReceiveLocation_URL	The Cast Iron Live URL that is used to receive service address data from Maximo.
SolutionManagerApiKey	The Analytics Solutions Manager on Cloud API key, which is used for authentication to make an HTTP POST request to Analytics Solutions Manager on Cloud. The API key is supplied in the customer Welcome package.
SolutionManagerHostName	The Analytics Solutions Manager on Cloud hostname/IP, which is used to make an HTTP POST request to the REST API of Analytics Solutions Manager on Cloud.

Table 10. MaximoMasterData_RealTime.par properties (continued)

Property name	Description
SolutionManagerPort	The Analytics Solutions Manager on Cloud port, which is used to make an HTTP POST request to the REST API of Analytics Solutions Manager on Cloud.
PostAsset_URL	The Analytics Solutions Manager on Cloud URL that is used to POST (push) asset/resource data. In the URL, replace `<project_id>` with the actual project ID.
PostGroupDim_URL	The Analytics Solutions Manager on Cloud URL that is used to POST (push) group dimension data. In the URL, replace `<project_id>` with the actual project ID.
PostLocation_URL	The Analytics Solutions Manager on Cloud URL that is used to POST (push) location data. In the URL, replace `<project_id>` with the actual project ID.

Properties of the MaximoWorkOrder_Batch.par project

The project contains the following properties:

Table 11. MaximoWorkOrder_Batch.par properties

Property name	Description
MaximoUser	The Maximo user name, which is used for authentication to make an HTTP GET request to Maximo.
MaximoPassword	The Maximo password, which is used for authentication to make an HTTP GET request to Maximo.
MaximoHostName	The Maximo hostname/IP, which is used to make an HTTP GET request to Maximo.
MaximoPort	The Maximo port, which is used to make an HTTP GET request to Maximo.
MaximoSecureConnector	The name of the secure connector that is configured to enable communication from Cast Iron Live to Maximo.
GetWorkOrder_SM_URL	The Maximo URL that is used to GET (pull) scheduled maintenance work order data.
GetWorkOrder_AM_URL	The Maximo URL that is used to GET (pull) actual maintenance work order data.
GetWorkOrder_BRK_URL	The Maximo URL that is used to GET (pull) breakdown work order data.
SolutionManagerApiKey	The Analytics Solutions Manager on Cloud API key, which is used for authentication to make an HTTP POST request to Analytics Solutions Manager on Cloud. The API key is supplied in the customer Welcome package.

Table 11. MaximoWorkOrder_Batch.par properties (continued)

Property name	Description
SolutionManagerHostName	The Analytics Solutions Manager on Cloud hostname/IP, which is used to make an HTTP POST request to the REST API of Analytics Solutions Manager on Cloud.
SolutionManagerPort	The Analytics Solutions Manager on Cloud port, which is used to make an HTTP POST request to the REST API of Analytics Solutions Manager on Cloud.
PostMaintenanceEvent_URL	The Analytics Solutions Manager on Cloud URL that is used to POST (push) Maintenance & Fail event data. In the URL, replace `<project_id>` with the actual project ID.

Properties of the MaximoWorkOrder_RealTime.par project

The project contains the following properties:

Table 12. MaximoWorkOrder_RealTime.par properties

Property name	Description
ReceiveWorkOrder_URL	The Cast Iron Live URL, which is used to receive work order data from Maximo.
SolutionManagerApiKey	The Analytics Solutions Manager on Cloud API key, which is used for authentication to make an HTTP POST request to Analytics Solutions Manager on Cloud. The API key is supplied in the customer Welcome package.
SolutionManagerHostName	The Analytics Solutions Manager on Cloud hostname/IP, which is used to make an HTTP POST request to the REST API of Analytics Solutions Manager on Cloud.
SolutionManagerPort	The Analytics Solutions Manager on Cloud port, which is used to make an HTTP POST request to the REST API of Analytics Solutions Manager on Cloud.
PostMaintenanceEvent_URL	The Analytics Solutions Manager on Cloud URL that is used to POST (push) Maintenance & Fail event data. In the URL, replace `<project_id>` with the actual project ID.

Properties of the MaximoMeterReading.par project

The project contains the following properties:

Table 13. MaximoMeterReading.par properties

Property name	Description
MaximoUser	The Maximo user name, which is used for authentication to make an HTTP GET request to Maximo.

Table 13. MaximoMeterReading.par properties (continued)

Property name	Description
MaximoPassword	The Maximo password, which is used for authentication to make an HTTP GET request to Maximo.
MaximoHostName	The Maximo hostname/IP, which is used to make an HTTP GET request to Maximo.
MaximoPort	The Maximo port, which is used to make an HTTP GET request to Maximo.
MaximoSecureConnector	The name of the secure connector that is configured to enable communication from Cast Iron Live to Maximo.
PostAssetMeter_URL	The Maximo URL that is used to POST (push) asset meter data.
PostMeterData_URL	The Maximo URL that is used to POST (push) meter data.

Configuration and system table artifacts

Metadata in the form of .csv files is used to create the configuration and system tables that are used by IBM Predictive Solutions Foundation on Cloud. You should never modify system tables but configuration tables can be modified to suit business needs. The .csv files defining the configuration and system tables can be found in the `source_connectors\config_data_sets` folder.

Configuration table artifacts

The configuration table artifacts are described in the following table:

Table 14. Configuration table artifacts

File name	Description
FeatureMapping.csv	Contains various features that need to be mapped for analytic models.
SourceSystem.csv	Contains data for source systems such as SENSOR and MAXIMO.
ValueType.csv	Contains data for various value types such as ACTUAL and FORECAST.

System table artifacts

The system table artifacts are described in the following table:

Table 15. System table artifacts

File name	Description
GroupDimension.csv	Contains the default values for Group Dimension.
Location.csv	Contains default values for Location.
ProfileCalculation.csv	Contains various calculations required to compute various profiles.

Table 15. System table artifacts (continued)

File name	Description
ProfileVariable.csv	Contains data for various profiles required during orchestrations for training analytic models and for processing analytic model results.

Appendix B. The Predictive Quality content pack and artifacts

The Predictive Quality content pack contains a collection of artifacts, such as database scripts, and XML configuration files. These artifacts support logical model, physical model and orchestrations, and connectors to invoke the algorithm and reports conveying the analysis. A content author can modify this content pack to meet business needs.

At the root of the content pack, there is a file named `solutionconfiguration.xml`. For each level of the logical model hierarchy, you can define associations to content artifacts to load data, run predictions, and visualize results. This file contains a catalog of all artifacts in your solution. For each content artifact, there is a version number and a name, and the categories it belongs to. For example:

```
<solutionDefinitionModel version="1.0"
        path="pmq_models/solution_definition/PMQ_solution_definition.xml"
        id="solutiondefinition" author="IBM"></solutionDefinitionModel>
```

If you change it, increment the version number.

```
<solutionDefinitionModel version="1.1"
        path="pmq_models/solution_definition/PMQ_solution_definition.xml"
        id="solutiondefinition" author="IBM"></solutionDefinitionModel>
```

To delete, remove a line.

Data model

The data model files for Predictive Quality are `IBMPMQ.sql` and `IBMPMQ_additional.sql`. They are in the `database_scripts` folder in the content pack.

`IBMPMQ.sql`
Contains the definition of physical data model such as master data table, event tables, KPI, and profile tables that are used for Predictive Quality.

`IBMPMQ_additional.sql`
Contains a stored procedure to initialize the calendar data and to populate a default language and tenant for the solution.

Analytics Solutions Foundation artifacts

Analytics Solutions Foundation enables you to define and manage aggregates and build the orchestration process to feed aggregated data into predictive models. Solutions created with Analytics Solutions Foundation consume events and make recommendations. They use profiles and key performance indicators to aggregate the events.

Maintenance Streams

The `logical_model` folder contains the following XML files:

`BaseLogicalModel.xml`
Contains the common data structures that are required for all of the business imperatives (predictive quality, predictive warranty, predictive maintenance) for defining and loading master data.

BaseQualityLogicalModel.xml
Contains the data structures that are common between the Quality Early Warning System use cases. (Inspection, Parametric and Warranty). The data structures help you to define a structure for loading the master data into the solution data store for the predictive quality imperative.

QualityLogicalModel.xml
Contains the definitions for entities and events which load data for Inspection and Parametric. Content authors can alter this logical model to define the measures they want to analyze using Parameteric algorithm. They can also define the variations for Inspection algorithm in this file. For example the sample content has example for `ProductInpsectionEvent` to analyze products using Inspection algorithm, and `MaterialInspectionEvent` to analyze material using Inspection algorithm. The event sub types defined for Inspection and Parametric become a sub use case for Inspection and Parametric analysis.

The `orchestration` folder contains the following XML files:

PMQ_Orchestration_definition_inspection.xml
Defines rules about how event or fact data is loaded into the solution data store for Inspection.

PMQ_Orchestration_definition_parametric.xml
Defines rules about how event data is loaded into the solution data store for Parametric.

PMQ_Orchestration_definition_quality_job.xml
Defines the steps to invoke the Quality algorithm. It is performed as part of Quality, Inspection, and Parametric analysis.

The `solution_definition` folder contains `PMQ_Solution_definition.xml`. This file defines the table and object structures that are used for defining the database. It also contains the definition for various calculations used during data load.

IBM Cognos Business Intelligence artifacts

IBM Cognos Business Intelligence on Cloud is a suite that provides tools to create reports and dashboards and build interactive analyses. A content author can develop new BI views and add them to the deployment archive provided in the default content pack.

Inspection report

The inspection report demonstrates real-time failure rate and cumulative sum (cusum) values obtained from algorithm along with H value as threshold level. You can run the inspection report by selecting a run date and the master parameter grain. The inspection report contains the following charts:

SPC chart
Plots the variations with respect to time.

Evidence chart
Enables the business community with early warning detections.

Parametric report

The parametric report monitors variable-type data and cusum values obtained from algorithm along with threshold levels. The parametric report supports the following validation types:

- Material Validation
- Process-Resource Validation
- Production Batch Validation
- Resource Health Check
- Location coduceability

The parametric report contains the following charts:

SPC chart
Plots the variable analysis rate by showing what happened at a particular time.

Evidence chart
Shows the early warning alarms when a drift in quality occurs.

Initial configuration files

Metadata in the form of .csv files is used to create the configuration tables that are used by IBM Predictive Solutions Foundation on Cloud. Configuration tables can be modified to suit business needs. The .csv files defining the configuration tables can be found in the `source_connectors\config_data_sets` folder.

Configuration table artifacts

The configuration table artifacts are described in the following table:

Table 16. Configuration table artifacts

File name	Description
`SourceSystem.csv`	Defines where the master or event data is streamed from, such as MAXIMO (enterprise asset management software) or SENSOR (if the source of the fact data is sensors).
`ValueType.csv`	Defines the types of values that the event data can bring in (Actual, Forecast, or Planned).

Predictive Quality sample data

Business Scenario for Inspection (Attribute Analysis)

Normally, in qualitative analysis techniques, a product, part, or material is run through a series of quality checks. The outcomes of the checks are tabulated, and based on the business guidelines they are labeled at different levels and sold in the market. Products, parts, or materials that do not succeed in the checks are labeled as flawed and are sent for further analysis. By using this practice, companies are in a reactive mode to analyze the cause before the flaw is propagated in the manufacturing line. This process is characterized by noise, turbulence, and loss. A potential consequence of quality gaps is a damaged reputation to the manufacturing company or unit.

This kind of scenario can be avoided if a mechanism is in place to identify product flaws long before they creep into large-scale distribution and subsequent recall. Such a system is called an early warning system, which identifies flaws much sooner so that there is enough time to take remedial measures.

IBM Predictive Quality offers an explicit early warning system through Inspection or Attribute analysis, when compared to normal statistical process control systems. This warning system takes the quantity inspected and the quantity failed as the major inputs, along with other inputs (called parameters) to control the analysis. The warning system prepares an evidence curve, which provides an early warning that is based on quality issues that are seen.

Sub Use Cases in Inspection

Inspection can be carried out on a product or a raw material. The following use cases are available:

- **ProductInspection use case (ProductInspectionEvent)** – The inspection or attribute analysis is carried out on a specific product, given the input data about the ratio of failed to tested products.
- **MaterialInspection use case (MaterialInspectionEvent)** – The focus is on the raw material that is procured from a vendor, given the input data about the ratio of failed to tested materials.

Business Scenario for Parametric (Variable Analysis)

The business challenges lie in identifying the rules to set up the quality norms for an end product or a raw material. Rules that fail to identify a product or material flaw cause noise and loss of confidence in quality. The more quality-related issues, the more damage to the business and costs incurred in replacements and servicing.

Applying complex statistical computation is a difficult task and it is hard to implement with available software. Normally, in a quality inspection process, quality is defined by a set of rules. Often those rules cannot identify subtle variations that occur during the manufacturing process. However, such variations are well handled by the Parametric or Variable analysis, where each and every measurement or observation is analyzed against its ideal value by defining the allowed level of deviation and drift. Whenever the observed deviation goes beyond the acceptable level or unacceptable level, it is flagged immediately. This helps in remediation of the flaw and improves the quality of the deliverables.

Sub Use Cases in Parametric

The Parametric Quality algorithm handles various master data sets, from raw materials to manufacturing machinery to end products, and environment or location-specific data. The following categories of analysis can be used on each of the master entities. Categories of analysis can be a combination of different masters or a lone entity.

- **Process Resource Validation (Unpreventable) -** Process Resource Validation is the default Parametric use case, in which the process, and the resource that takes part in process, are monitored based on a defined set of measurement types (variables). These variables are compared against target values, acceptable limits, unacceptable limits, standard deviation, false alarm rates, and unacceptable factors.

- **Resource Validation (RVariableEvent) -** In the Resource Validation use case, a resource is monitored based on the standard operation limits across several measurement types (variables). This kind of health check is essential in identifying issues in the resource and to remediate to improve performance and throughput.
- **Product Validation (PBVariableEvent) -** In the Product Validation use case, given a set of variables whose targets are set for the product to meet, any deviation or drift beyond the allowed deviation highlights flaws in the product.
- **Material Validation (MVariableEvent) -** In the Material Validation use case, raw materials that are purchased from a vendor are monitored for a defined set of guidelines and are validated to check the quality of the procured material.
- **Location Conduce-ability (LVariableEvent) -** In the Location Conduceability use case, a location can be analyzed for its suitability to a particular operation. Time slide values (that is, observations that were recorded at specific time intervals) are considered for variables like pressure, temperature, and humidity.

Input Files for Predictive Quality

There are three major types of input files:

- Configuration files
  - Logical model files
  - Orchestration files
  - Solution definition files
- Master CSV files
- Event CSV files

Configuration files

The Quality logical model xml file (in the logicalmodel folder) contains the way in which the CSV files must be structured. This xml file defines the structure for each Master data entity and event data entity. The triggering mechanisms are common for both the Quality use cases (Inspection and Parametric). Master and Event data entities are mapped to the appropriate Master table that is defined in the Predictive Quality data model.

For example, the master entity Product (of the Inspection use case) is defined as follows:

```
<entity code="Product" description="Represents a product" displayName="Product" extendable="false"
    <instanceTableMap instanceTableCode="MASTER_PRODUCT" />
    <attribute code="ProductCode" displayName="Product Code" columnCode="PRODUCT_CD" dataType="str
    <attribute code="ProductName" displayName="Product Name" columnCode="PRODUCT_NAME" dataType="s
    <attribute code="ProductTypeCode" displayName="Product Type Code" columnCode="PRODUCT_TYPE_CD"
    <attribute code="ProductTypeName" displayName="Product Type Name" columnCode="PRODUCT_TYPE_NAM
    <attribute code="IsActive" displayName="Is Active" columnCode="IS_ACTIVE" dataType="boolean" i
    <selfReference columnCode="PARENT_PRODUCT_ID">
      <attribute code="ParentProductCode" dataType="string" description="Parent Product Code" disp
      <attribute code="ParentProductTypeCode" dataType="string" description="Parent Product Type C
    </selfReference>
</entity>
```

The columns for the master entity Product appear as attributes and those cyclic references or self references are defined for the product itself. The mapping to the table MASTER_PRODUCT is in the instanceTableMap tag.

The master_parameter_grain table provides a grain identity for a unique combination of location, product, production batch, resource, process, material, and measurement type. Measurement type (such as temperature, pressure, or humidity) is tightly coupled to event type, so when an event type is defined, a measurement type is also defined as its attribute.

The master_parameter table contains the parameters, such as LAM0, LAM1, and PROB0. The master_parameter and master_parameter_grain tables are joined in the master_parameter_value table. The value for each event's measurement type is loaded in the master_parameter_value table.

The following example shows the definition of the parameter grain in the logical model, and the parameters that are used for the Parametric use case:

```
<entity code="Parameter" description="Parameter" displayName="Parameter" extendable="true" id="" vers
        <typeTableMap typeTableCode="MASTER_MODEL_TYPE" typeCodeColumnRef="MODEL_TYPE_CD" typeParent
        <attributeTableMap attributeTableCode="MASTER_PARAMETER" attributeCodeColumnRef="PARAMETER_C
        <instanceTableMap instanceTableCode="MASTER_PARAMETER_GRAIN"/>
        <attributeValueTableMap attributeValueTableCode="MASTER_PARAMETER_VALUE" attributeCodeColumn
<reference entityRef="Location" isRequired="true" columnCode="LOCATION_ID" isKey="true">
        <attribute code="Location" description="Location" displayName="Location" dataType="string" a
        </reference>
                <reference entityRef="Resource" isRequired="true" columnCode="RESOURCE_ID" isKey="tr
                      <attribute code="ResourceCd1" description="Resource Code 1" displayName="Resou
                      <attribute code="ResourceCd2" description="Resource Code 2" displayName="Resou
                </reference>
                <reference entityRef="Product" isRequired="true" columnCode="PRODUCT_ID" isKey="true"
                      <attribute code="ProductCode" description="Product Code" displayName="Product
                      <attribute code="ProductTypeCode" description="Product Type Code" displayName=
                </reference>
                <reference entityRef="Process" isRequired="true" columnCode="PROCESS_ID" isKey="true"
                      <attribute code="ProcessCode" description="Process Code" displayName="Process
                </reference>
               <reference entityRef="ProductionBatch" isRequired="true" columnCode="PRODUCTION_BATCH_
                      <attribute code="ProductionBatchCode" description="Production Batch Code" disp
               </reference>
               <reference entityRef="Material" isRequired="true" columnCode="MATERIAL_ID" isKey="tru
                       <attribute code="MaterialCode" description="Material Code" displayName="Mater
               </reference>
               <reference entityRef="MeasurementType" isRequired="true" columnCode="MEASUREMENT_TYPE_
                      <attribute code="MeasurementTypeCode" description="Measurement Type Code" disp
                       <attribute dataType="string" code="EventTypeCode" description="Event Type Cod
               </reference>
</entity>
```

The following xml definition extends the Parameter definition. The CSV file for Inspection parameters is defined such that the first set of columns carries all the master entity references for defining a parameter grain, and the next extended part carries the parameters (as attributes) as column names (LAM0, LAM1, PROB0). This defines a parameter grain and parameters to the grain in one row of the CSV file.

```
<entitySubType code="Inspection" description="Inspection" displayName="Inspection" extends="Paramete
      <attribute code="LAM0" displayName="LAM 0" dataType="double" description="LAM 0" isRequired="t
      <attribute code="LAM1" displayName="LAM 1" dataType="double" description="LAM 1" isRequired="t
      <attribute code="PROB0" displayName="PROB 0" dataType="double" description="PROB 0" isRequired
      <attribute code="INSPECT_NO_DAYS" displayName="Number of days" dataType="double" description="
</entitySubType>
```

Event entities are defined in a similar way. The master reference grains under QualityEvent and this entity type are extended by ProductInspectionEvent and MaterialInspectionEvent. Both the ProductInspectionEvent and MaterialInspectionEvent carry attributes for quantity produced (QTY), quantity inspected (INSPECT), and the quantity failed (FAIL). This appears in the CSV following the event structure that was inherited.

```
<eventSubType code="ProductInspectionEvent" description="Represents a inspection event for Product
      <attribute code="QTY" displayName="Quantity Produced" dataType="double" description="Quantit
      <attribute code="INSPECT" displayName="Number of Inspected Quantity" dataType="double" descr
      <attribute code="FAIL" displayName="Number of Fail Quantity" dataType="double" description="
</eventSubType>
```

Orchestration files (in the orchestration folder) are also important to configuration. There are three orchestration files: one for handling Inspection related event data persistence to the Predictive Quality Event store; one for handling Parametric events data persistence to the Predictive Quality Event store; and one for triggering the Quality analysis. Inspection and Parametric are handled in sequence.

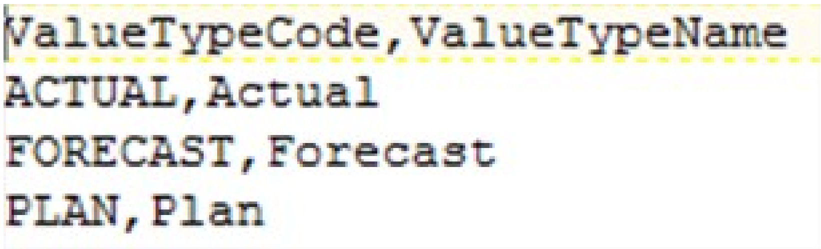
The final configuration file is the solution definition xml file. This file defines all the table structures that are part of the Predictive Quality and Predictive Warranty data store.

Master CSV files

The Master CSV files carry all the master data set or entity data set whose various observations or measurements are recorded and analyzed. For the sake of Predictive Quality, the following are the required Master data sets that must be loaded before any fact data is loaded.

The list of CSV files to be loaded in sequence is:

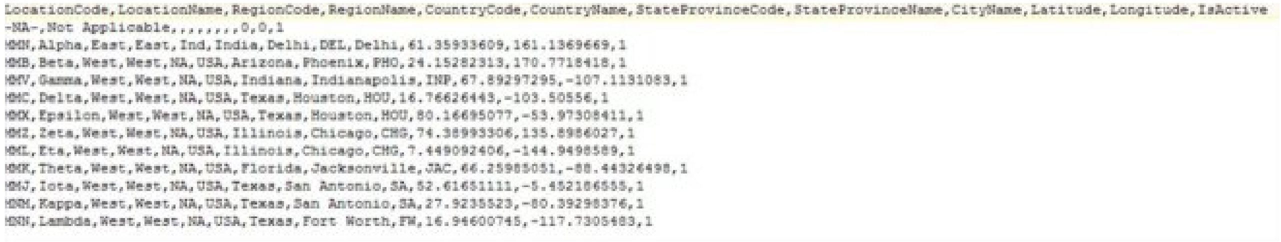
1. **Master_Value_type** - The Value type offers only three values: ACTUAL, PLAN, and FORECAST. Normally, the data associated with inspection or parametric events are only ACTUAL.



```
ValueTypeCode,ValueTypeName
ACTUAL,Actual
FORECAST,Forecast
PLAN,Plan
```

Figure 2. Master_Value_type

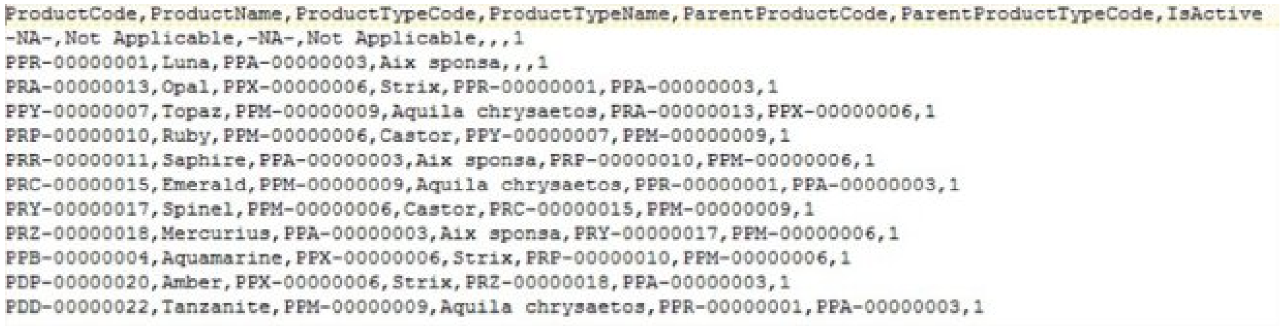
2. **Master_Location** - The Location data holds information that is specific to the geography of the location where the event is produced, or the resource that produces the events.



```
LocationCode,LocationName,RegionCode,RegionName,CountryCode,CountryName,StateProvinceCode,StateProvinceName,CityName,Latitude,Longitude,IsActive
-NA-,Not Applicable,,,,,,,,0,0,1
HMN,Alpha,East,East,Ind,India,Delhi,DEL,Delhi,61.35933609,161.1369669,1
HMB,Beta,West,West,NA,USA,Arizona,Phoenix,PHO,24.15282313,170.7718418,1
HMV,Gamma,West,West,NA,USA,Indiana,Indianapolis,INP,67.89297295,-107.1131083,1
HMC,Delta,West,West,NA,USA,Texas,Houston,HOU,16.76626443,-103.50556,1
HMX,Epsilon,West,West,NA,USA,Texas,Houston,HOU,80.16695077,-53.97308411,1
HMZ,Zeta,West,West,NA,USA,Illinois,Chicago,CHG,74.38993306,135.8986027,1
HML,Eta,West,West,NA,USA,Illinois,Chicago,CHG,7.449092406,-144.9498589,1
HMK,Theta,West,West,NA,USA,Florida,Jacksonville,JAC,66.25985051,-88.44326498,1
HMJ,Iota,West,West,NA,USA,Texas,San Antonio,SA,52.61651111,-5.452186555,1
HNM,Kappa,West,West,NA,USA,Texas,San Antonio,SA,27.9235523,-80.39298376,1
HNN,Lambda,West,West,NA,USA,Texas,Fort Worth,FW,16.94600745,-117.7305483,1
```

Figure 3. Master_Location

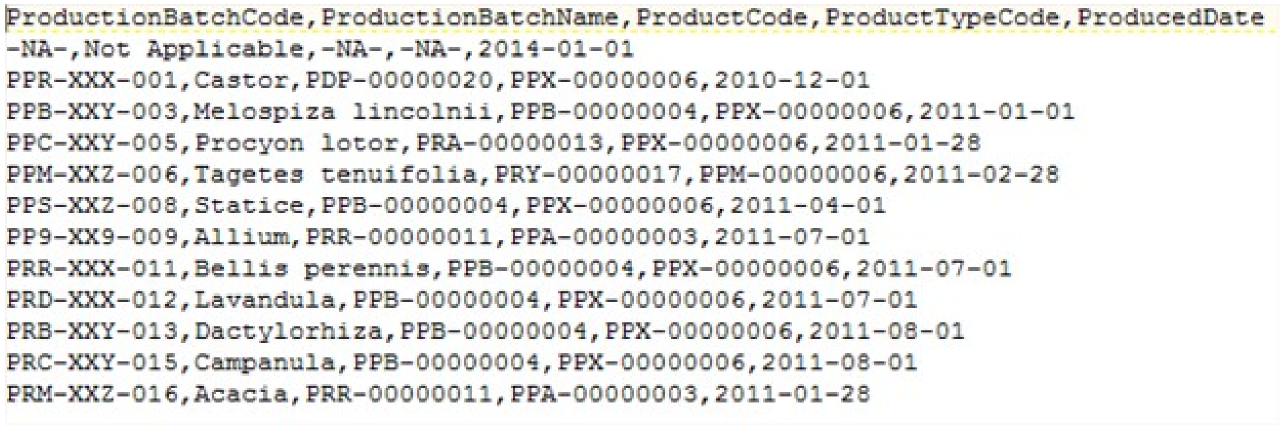
3. **Master product** - This table forms the core data for the inspection use case. This table stores product-related information along with the information of what product_type it is.



```
ProductCode,ProductName,ProductTypeCode,ProductTypeName,ParentProductCode,ParentProductTypeCode,IsActive
-NA-,Not Applicable,-NA-,Not Applicable,,,1
PPR-00000001,Luna,PPA-00000003,Aix sponsa,,,1
PRA-00000013,Opal,PPX-00000006,Strix,PPR-00000001,PPA-00000003,1
PPY-00000007,Topaz,PPM-00000009,Aquila chrysaetos,PRA-00000013,PPX-00000006,1
PRP-00000010,Ruby,PPM-00000006,Castor,PPY-00000007,PPM-00000009,1
PRR-00000011,Saphire,PPA-00000003,Aix sponsa,PRP-00000010,PPM-00000006,1
PRC-00000015,Emerald,PPM-00000009,Aquila chrysaetos,PPR-00000001,PPA-00000003,1
PRY-00000017,Spinel,PPM-00000006,Castor,PRC-00000015,PPM-00000009,1
PRZ-00000018,Mercurius,PPA-00000003,Aix sponsa,PRY-00000017,PPM-00000006,1
PPB-00000004,Aquamarine,PPX-00000006,Strix,PRP-00000010,PPM-00000006,1
PDP-00000020,Amber,PPX-00000006,Strix,PRZ-00000018,PPA-00000003,1
PDD-00000022,Tanzanite,PPM-00000009,Aquila chrysaetos,PPR-00000001,PPA-00000003,1
```

Figure 4. Master_Product

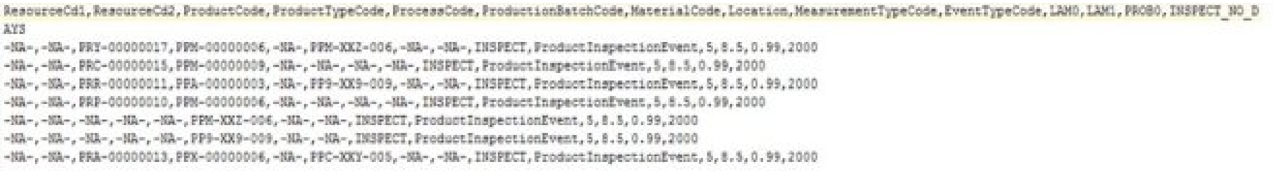
4. **Master_ProductionBatch** - This table maintains information about each production batch that is used to produce the desired products. It maintains details like which product is produced, at what date it is produced, and the batch information.



```
ProductionBatchCode,ProductionBatchName,ProductCode,ProductTypeCode,ProducedDate
-NA-,Not Applicable,-NA-,-NA-,2014-01-01
PPR-XXX-001,Castor,PDP-00000020,PPX-00000006,2010-12-01
PPB-XXY-003,Melospiza lincolnii,PPB-00000004,PPX-00000006,2011-01-01
PPC-XXY-005,Procyon lotor,PRA-00000013,PPX-00000006,2011-01-28
PPM-XXZ-006,Tagetes tenuifolia,PRY-00000017,PPM-00000006,2011-02-28
PPS-XXZ-008,Statice,PPB-00000004,PPX-00000006,2011-04-01
PP9-XX9-009,Allium,PRR-00000011,PPA-00000003,2011-07-01
PRR-XXX-011,Bellis perennis,PPB-00000004,PPX-00000006,2011-07-01
PRD-XXX-012,Lavandula,PPB-00000004,PPX-00000006,2011-07-01
PRB-XXY-013,Dactylorhiza,PPB-00000004,PPX-00000006,2011-08-01
PRC-XXY-015,Campanula,PPB-00000004,PPX-00000006,2011-08-01
PRM-XXZ-016,Acacia,PRR-00000011,PPA-00000003,2011-01-28
```

Figure 5. Master production batch

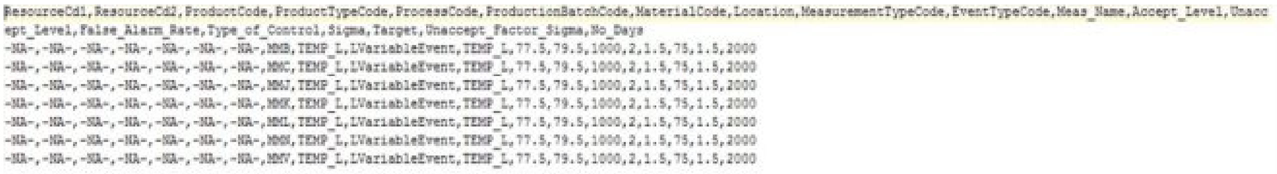
5. **ProductInspectionParameter CSV** - This CSV file contains all the master entity grains for which parameters must be defined. A sample of the product parameters snapshot is shown below.



```
ResourceCd1,ResourceCd2,ProductCode,ProductTypeCode,ProcessCode,ProductionBatchCode,MaterialCode,Location,MeasurementTypeCode,EventTypeCode,LAM0,LAM1,PROB0,INSPECT_NO_D
AYS
-NA-,-NA-,PRY-00000017,PPM-00000006,-NA-,PPM-XXZ-006,-NA-,-NA-,INSPECT,ProductInspectionEvent,5,8.5,0.99,2000
-NA-,-NA-,PRC-00000015,PPM-00000009,-NA-,-NA-,-NA-,-NA-,INSPECT,ProductInspectionEvent,5,8.5,0.99,2000
-NA-,-NA-,PRR-00000011,PPA-00000003,-NA-,PP9-XX9-009,-NA-,-NA-,INSPECT,ProductInspectionEvent,5,8.5,0.99,2000
-NA-,-NA-,PRP-00000010,PPM-00000006,-NA-,-NA-,-NA-,-NA-,INSPECT,ProductInspectionEvent,5,8.5,0.99,2000
-NA-,-NA-,-NA-,-NA-,-NA-,PPM-XXZ-006,-NA-,-NA-,INSPECT,ProductInspectionEvent,5,8.5,0.99,2000
-NA-,-NA-,-NA-,-NA-,-NA-,PP9-XX9-009,-NA-,-NA-,INSPECT,ProductInspectionEvent,5,8.5,0.99,2000
-NA-,-NA-,PRA-00000013,PPX-00000006,-NA-,PPC-XXY-005,-NA-,-NA-,INSPECT,ProductInspectionEvent,5,8.5,0.99,2000
```

Figure 6. Product inspection parameter

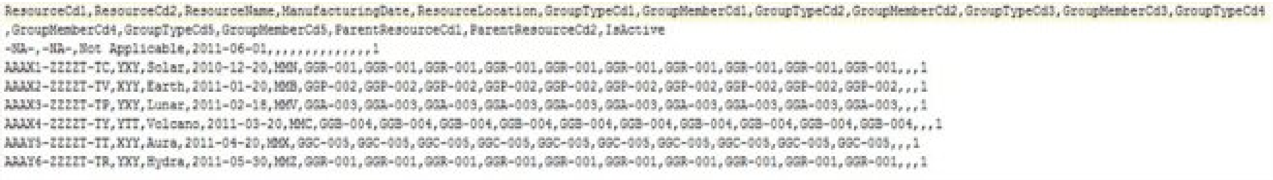
Similarly, sample parameter data for Parametric (for location use case) based snapshot is shown below.



```
ResourceCd1,ResourceCd2,ProductCode,ProductTypeCode,ProcessCode,ProductionBatchCode,MaterialCode,Location,MeasurementTypeCode,EventTypeCode,Meas_Name,Accept_Level,Unacc
ept_Level,False_Alarm_Rate,Type_of_Control,Sigma,Target,Unaccept_Factor_Sigma,No_Days
-NA-,-NA-,-NA-,-NA-,-NA-,-NA-,-NA-,MMB,TEMP_L,LVariableEvent,TEMP_L,77.5,79.5,1000,2,1.5,75,1.5,2000
-NA-,-NA-,-NA-,-NA-,-NA-,-NA-,-NA-,MMC,TEMP_L,LVariableEvent,TEMP_L,77.5,79.5,1000,2,1.5,75,1.5,2000
-NA-,-NA-,-NA-,-NA-,-NA-,-NA-,-NA-,MMJ,TEMP_L,LVariableEvent,TEMP_L,77.5,79.5,1000,2,1.5,75,1.5,2000
-NA-,-NA-,-NA-,-NA-,-NA-,-NA-,-NA-,MMK,TEMP_L,LVariableEvent,TEMP_L,77.5,79.5,1000,2,1.5,75,1.5,2000
-NA-,-NA-,-NA-,-NA-,-NA-,-NA-,-NA-,MML,TEMP_L,LVariableEvent,TEMP_L,77.5,79.5,1000,2,1.5,75,1.5,2000
-NA-,-NA-,-NA-,-NA-,-NA-,-NA-,-NA-,MMN,TEMP_L,LVariableEvent,TEMP_L,77.5,79.5,1000,2,1.5,75,1.5,2000
-NA-,-NA-,-NA-,-NA-,-NA-,-NA-,-NA-,MMV,TEMP_L,LVariableEvent,TEMP_L,77.5,79.5,1000,2,1.5,75,1.5,2000
```

Figure 7. Sample parameter data for Parametric

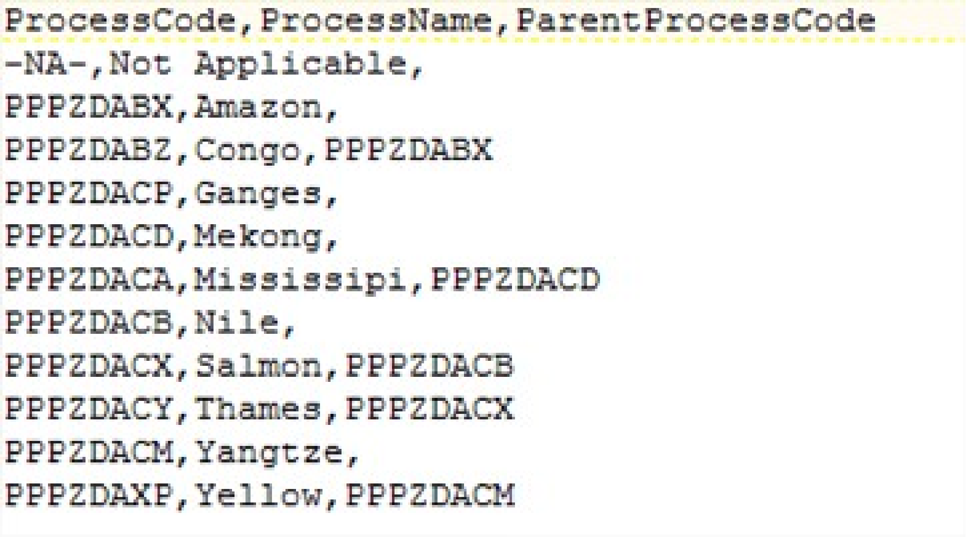
6. **Master Resource** - Master Resource must be loaded if you have to carry out a granular analysis of Inspection or a parametric use case of Resource Validation or Process Resource Validation.



```
ResourceCd1,ResourceCd2,ResourceName,ManufacturingDate,ResourceLocation,GroupTypeCd1,GroupMemberCd1,GroupTypeCd2,GroupMemberCd2,GroupTypeCd3,GroupMemberCd3,GroupTypeCd4
,GroupMemberCd4,GroupTypeCd5,GroupMemberCd5,ParentResourceCd1,ParentResourceCd2,IsActive
-NA-,-NA-,Not Applicable,2011-06-01,,,,,,,,,,,,,,1
AAAX1-ZZZZT-TC,YXY,Solar,2010-12-20,MMN,GGR-001,GGR-001,GGR-001,GGR-001,GGR-001,GGR-001,GGR-001,GGR-001,GGR-001,GGR-001,,,1
AAAX2-ZZZZT-TV,XYY,Earth,2011-01-20,MMB,GGP-002,GGP-002,GGP-002,GGP-002,GGP-002,GGP-002,GGP-002,GGP-002,GGP-002,GGP-002,,,1
AAAX3-ZZZZT-TP,YXY,Lunar,2011-02-18,MMV,GGA-003,GGA-003,GGA-003,GGA-003,GGA-003,GGA-003,GGA-003,GGA-003,GGA-003,GGA-003,,,1
AAAX4-ZZZZT-TY,YTT,Volcano,2011-03-20,MMC,GGB-004,GGB-004,GGB-004,GGB-004,GGB-004,GGB-004,GGB-004,GGB-004,GGB-004,GGB-004,,,1
AAAY5-ZZZZT-TT,XYY,Aura,2011-04-20,MMX,GGC-005,GGC-005,GGC-005,GGC-005,GGC-005,GGC-005,GGC-005,GGC-005,GGC-005,GGC-005,,,1
AAAY6-ZZZZT-TR,YXY,Hydra,2011-05-30,MMZ,GGR-001,GGR-001,GGR-001,GGR-001,GGR-001,GGR-001,GGR-001,GGR-001,GGR-001,GGR-001,,,1
```

Figure 8. Master resource

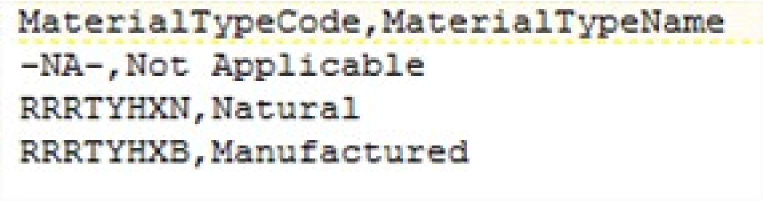
7. **Master Process** - Master Process CSV file is for any granular approach of inspection or parametric.



```
ProcessCode,ProcessName,ParentProcessCode
-NA-,Not Applicable,
PPPZDABX,Amazon,
PPPZDABZ,Congo,PPPZDABX
PPPZDACP,Ganges,
PPPZDACD,Mekong,
PPPZDACA,Mississipi,PPPZDACD
PPPZDACB,Nile,
PPPZDACX,Salmon,PPPZDACB
PPPZDACY,Thames,PPPZDACX
PPPZDACM,Yangtze,
PPPZDAXP,Yellow,PPPZDACM
```

Figure 9. Master process

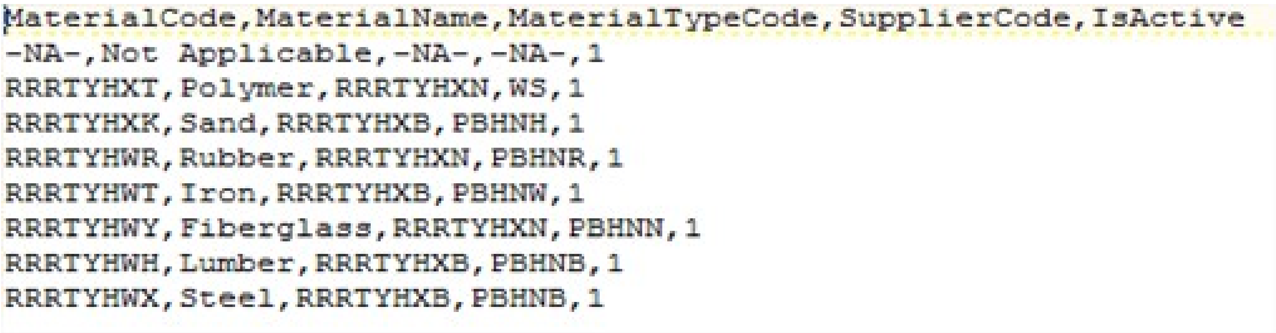
8. **Master Material Type** - Master material type is required for loading the material data and it is required for Inspection or Parametric analysis.



```
MaterialTypeCode,MaterialTypeName
-NA-,Not Applicable
RRRTYHXN,Natural
RRRTYHXB,Manufactured
```

Figure 10. Master material type

9. **Master Material** - Master Material is required for inspection or parametric analysis.



```
MaterialCode,MaterialName,MaterialTypeCode,SupplierCode,IsActive
-NA-,Not Applicable,-NA-,-NA-,1
RRRTYHXT,Polymer,RRRTYHXN,WS,1
RRRTYHXK,Sand,RRRTYHXB,PBHNH,1
RRRTYHWR,Rubber,RRRTYHXN,PBHNR,1
RRRTYHWT,Iron,RRRTYHXB,PBHNW,1
RRRTYHWY,Fiberglass,RRRTYHXN,PBHNN,1
RRRTYHWH,Lumber,RRRTYHXB,PBHNB,1
RRRTYHWX,Steel,RRRTYHXB,PBHNB,1
```

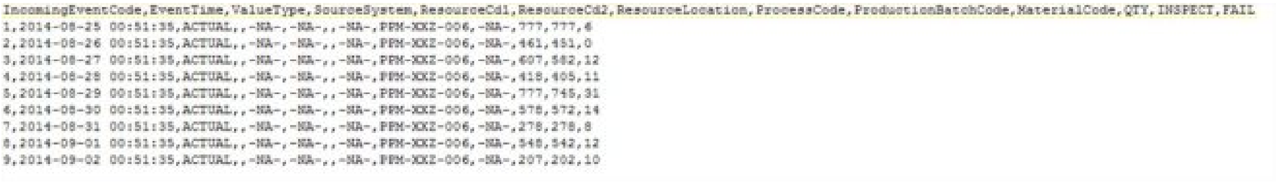
Figure 11. Master material

The event types and measurement types are inserted as a part of logical model.xml. Normally, when the logical model is defined, it covers all the event types, and each measurement type acts as an attribute to it. Therefore, they are loaded by the foundation system without any explicit use of CSV.

Event CSV files

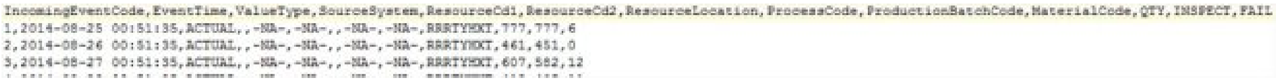
These fact data sets carry the list of observations done for any particular event that requires significant attention for further analysis or scoring or training. For Predictive Quality, there is one event data set file for Inspection and one for each use case of Parametric.

For Inspection, there are two sub use cases like ProductInspectionEvent and MaterialInspectionEvent. Both have a similar structure; the only thing that differentiates them are the entity that gains focus. ProductInspectionEvent, focuses on the production batch that is being used, while MaterialInspectionEvent focuses on the Material entity under consideration. The snapshots for both are shown below.



```
IncomingEventCode,EventTime,ValueType,SourceSystem,ResourceCd1,ResourceCd2,ResourceLocation,ProcessCode,ProductionBatchCode,MaterialCode,QTY,INSPECT,FAIL
1,2014-08-25 00:51:35,ACTUAL,,-NA-,-NA-,,-NA-,PPM-XXZ-006,-NA-,777,777,6
2,2014-08-26 00:51:35,ACTUAL,,-NA-,-NA-,,-NA-,PPM-XXZ-006,-NA-,461,451,0
3,2014-08-27 00:51:35,ACTUAL,,-NA-,-NA-,,-NA-,PPM-XXZ-006,-NA-,607,582,12
4,2014-08-28 00:51:35,ACTUAL,,-NA-,-NA-,,-NA-,PPM-XXZ-006,-NA-,418,405,11
5,2014-08-29 00:51:35,ACTUAL,,-NA-,-NA-,,-NA-,PPM-XXZ-006,-NA-,777,745,31
6,2014-08-30 00:51:35,ACTUAL,,-NA-,-NA-,,-NA-,PPM-XXZ-006,-NA-,578,572,14
7,2014-08-31 00:51:35,ACTUAL,,-NA-,-NA-,,-NA-,PPM-XXZ-006,-NA-,278,278,8
8,2014-09-01 00:51:35,ACTUAL,,-NA-,-NA-,,-NA-,PPM-XXZ-006,-NA-,548,542,12
9,2014-09-02 00:51:35,ACTUAL,,-NA-,-NA-,,-NA-,PPM-XXZ-006,-NA-,207,202,10
```

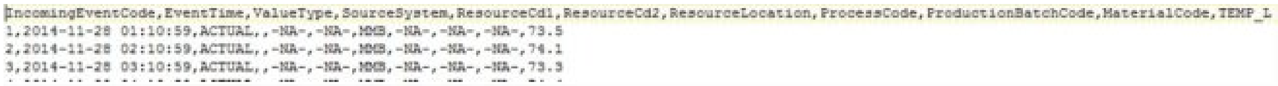
Figure 12. Product inspection event



```
IncomingEventCode,EventTime,ValueType,SourceSystem,ResourceCd1,ResourceCd2,ResourceLocation,ProcessCode,ProductionBatchCode,MaterialCode,QTY,INSPECT,FAIL
1,2014-08-25 00:51:35,ACTUAL,,-NA-,-NA-,,-NA-,-NA-,RRRTYHXT,777,777,6
2,2014-08-26 00:51:35,ACTUAL,,-NA-,-NA-,,-NA-,-NA-,RRRTYHXT,461,451,0
3,2014-08-27 00:51:35,ACTUAL,,-NA-,-NA-,,-NA-,-NA-,RRRTYHXT,607,582,12
```

Figure 13. Material inspection event

There are five Parametric events, they are LocationValidation (LVariableEvent), ResourceValidation (RVariableEvent), ProcessResourceValidation (PRVariableEvent), MaterialValidation (MVariableEvent), and ProductionBatchValidation or ProductValidation (PBValidationEvent). LocationValidation sample set is shown below.



```
IncomingEventCode,EventTime,ValueType,SourceSystem,ResourceCd1,ResourceCd2,ResourceLocation,ProcessCode,ProductionBatchCode,MaterialCode,TEMP_L
1,2014-11-28 01:10:59,ACTUAL,,-NA-,-NA-,MMB,-NA-,-NA-,-NA-,73.5
2,2014-11-28 02:10:59,ACTUAL,,-NA-,-NA-,MMB,-NA-,-NA-,-NA-,74.1
3,2014-11-28 03:10:59,ACTUAL,,-NA-,-NA-,MMB,-NA-,-NA-,-NA-,73.3
```

Figure 14. Location validation

Arguments passed while triggering the Quality Analysis

Quality Analysis triggers Inspection and Parametric analysis in sequence. Both analyses have similar arguments.

For Inspection, the arguments are:

1. INSPECTION_RUNDATE – This is the date up to which to process information in the subusecase. The value can be today's date or a prior date.
2. INSPECTION_SUBUSECASE – This is a sub use case of Inspection, where either it could be ProductInspectionEvent or MaterialInspectionEvent.

For Parametric, the arguments are:

1. PARAMETRIC_RUNDATE – This is the date up to which to process information in the subusecase. The value can be today's date or a prior date.
2. PARAMETRIC_SUBUSECASE – This can take either of the values in LVARIABLE, RVARIABLE, MVARIABE, PBVARIABLE, or PRVARIABLE.

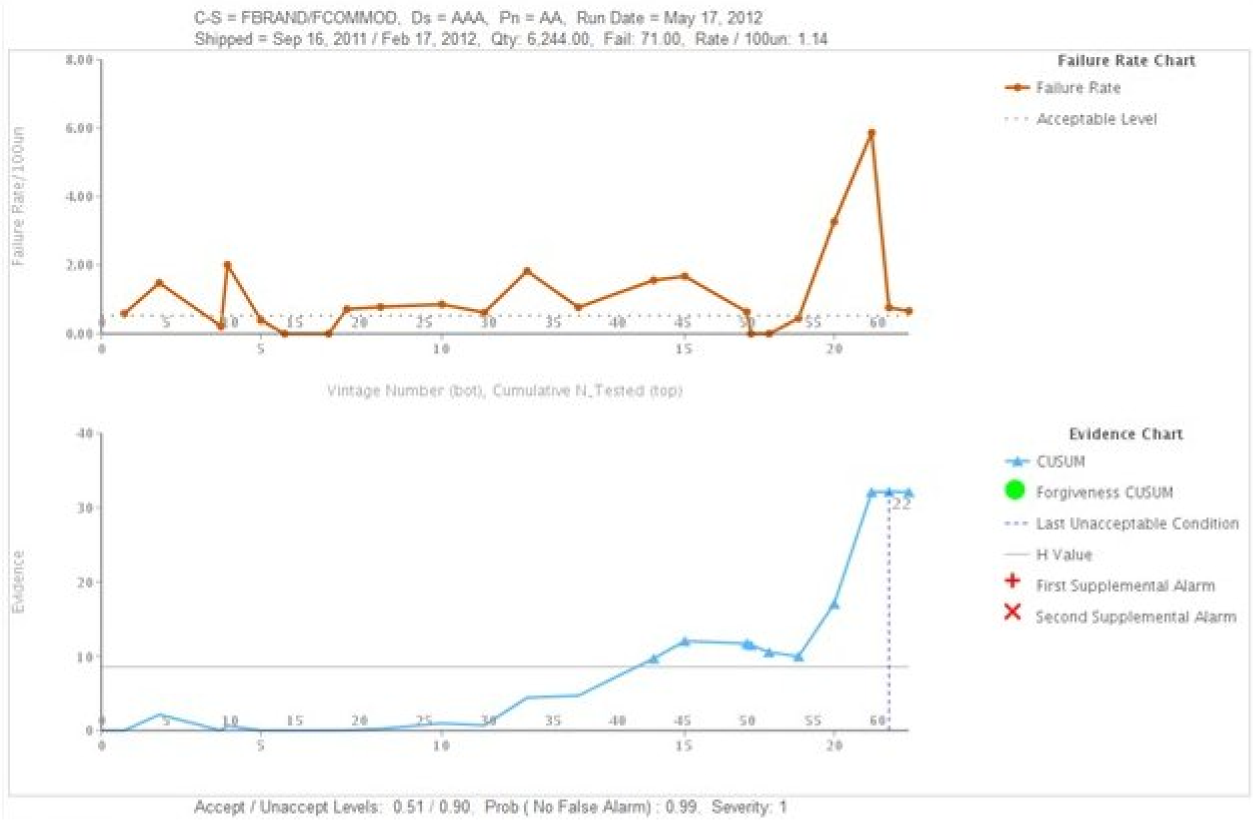
Interpreting the Inspection chart

There are two charts shown by the reports.

The first chart is called the Failure Rate Chart or a Statistical Process Control chart. The chart has a dual-scale X axis. The bottom scale is the Vintage number. The top scale is the cumulative quantity that is tested. The Y axis scale is Failure rate per 100 units. The orange line graph represents the association of failure rate against the Vintage number or the tested quantity. The white dotted line that is parallel to the X axis is the acceptable mean of failure. As per statistical norms, whenever the line graph climbs over the acceptable mean of failure, it signifies that the quality of the product or the entity under consideration is going out of the accepted tolerance level. This is a reactive mechanism, where measures of remediation can only take place when the first instance when the curve crosses the acceptance level.

The second chart is called the Evidence Chart. The Evidence chart is proprietary to IBM Research. In the Evidence chart, the X axis shares the same scales as SPC charts. The Y axis scale is Cumulative sum (cusum) of failures. The blue line graph represents the cusum curve that is plotted relating the cusum of failure rates with the vintage number or the tested quantity. The thick white line that is parallel to the X axis is the Threshold of acceptance, which is built on cusum of failure rates. The line graph has triangle markings once it crosses the threshold line. The first instance where the line crosses the threshold is called the first alarm signal. On the right side of the chart there is a blue dotted vertical line, parallel to the Y axis. This line denotes the highest unacceptable level that the vintage has reached. The gap in the X axis between the last vintage to this highest unacceptable level is called the RCUN (return code for unacceptable condition) value. A descent of the curve after the highest unacceptable condition is called forgiveness factor. The forgiveness factor enables the possibility for the curve to return to normalcy. If the highest unacceptable condition occurred at the date when the analysis was run, then there is no forgiveness factor because the condition might continue to worsen after that date.

Product- AAA



C-S = FBRAND/FCOMMOD, Ds = AAA, Pn = AA, Run Date = May 17, 2012
Shipped = Sep 16, 2011 / Feb 17, 2012, Qty: 6,244.00, Fail: 71.00, Rate / 100un: 1.14

Accept / Unaccept Levels: 0.51 / 0.90, Prob (No False Alarm) : 0.99, Severity: 1

Figure 15. Inspection chart 1

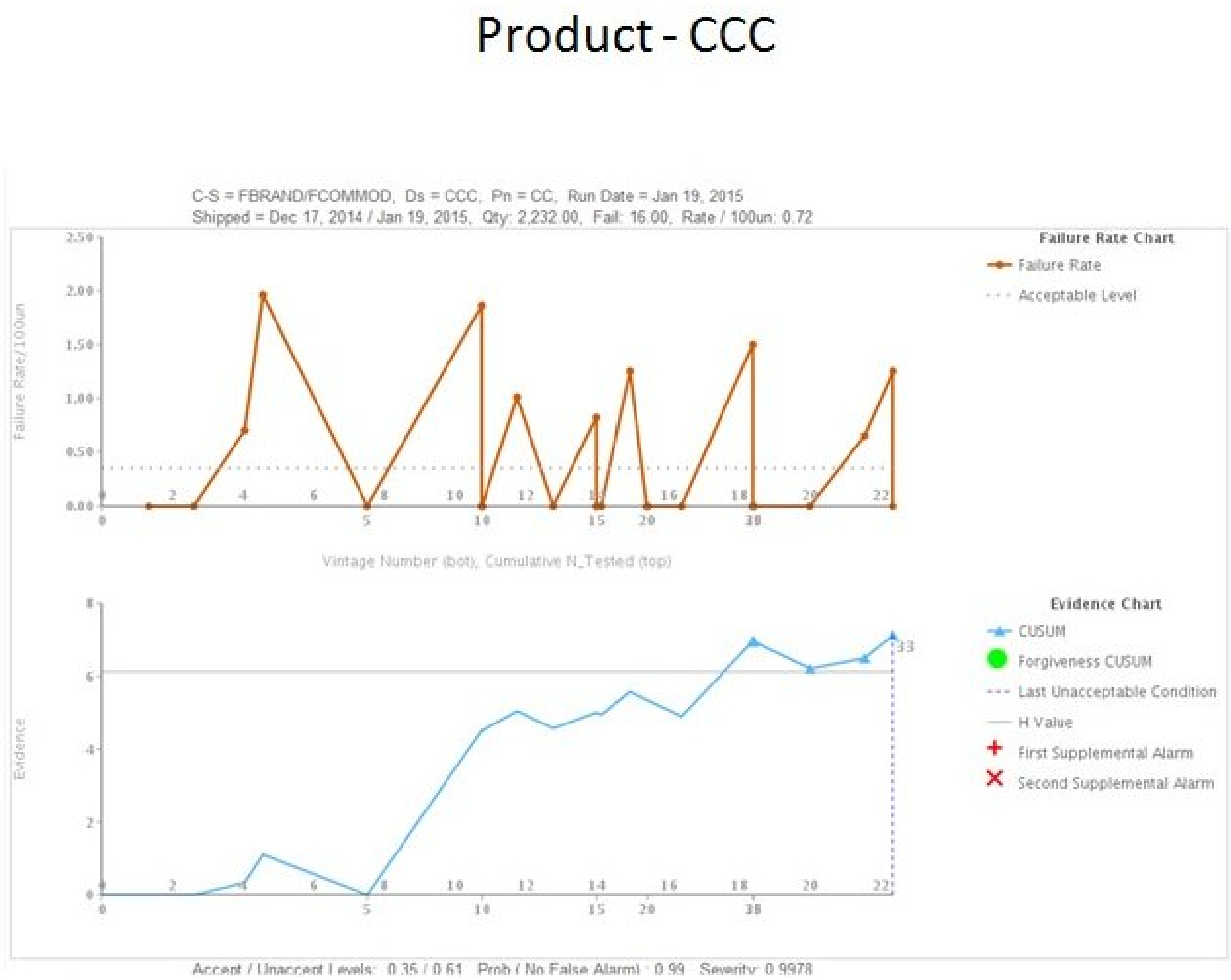
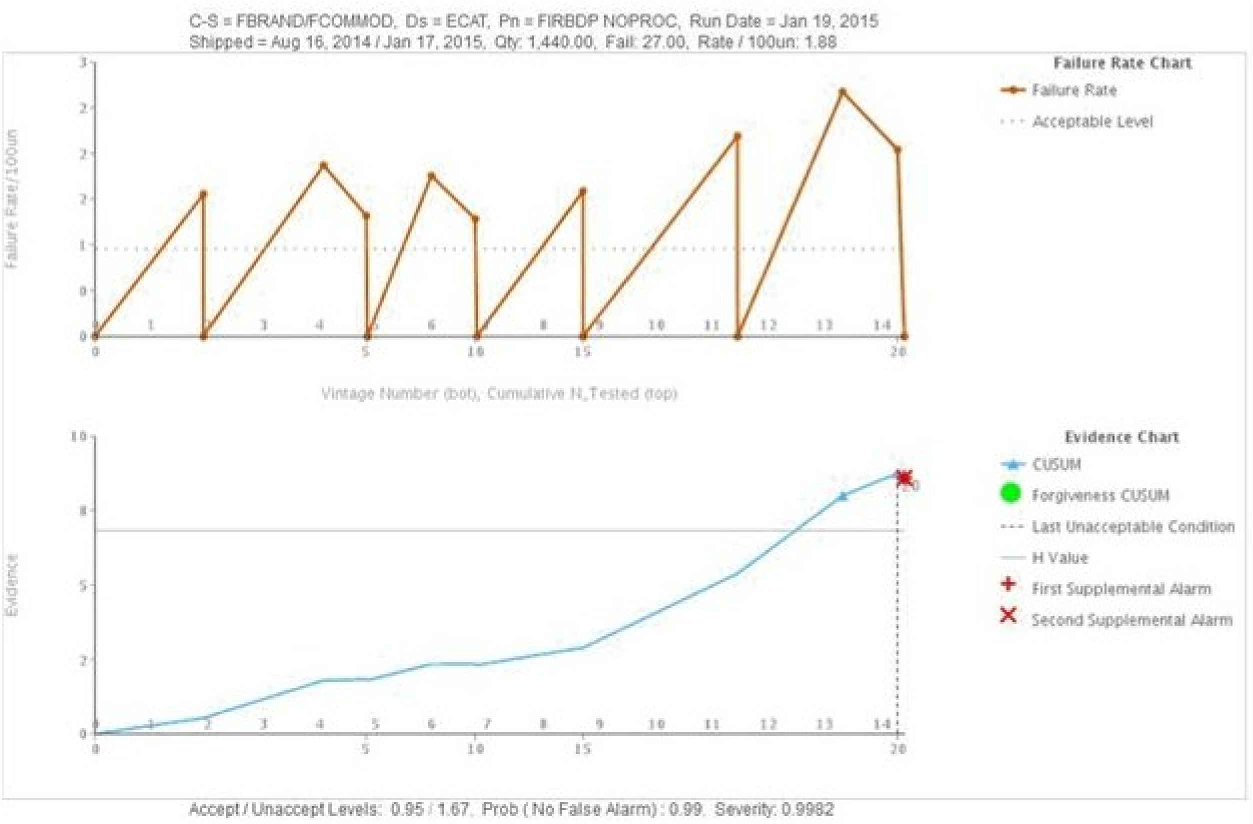


Figure 16. Inspection chart 2

Product- ECAT

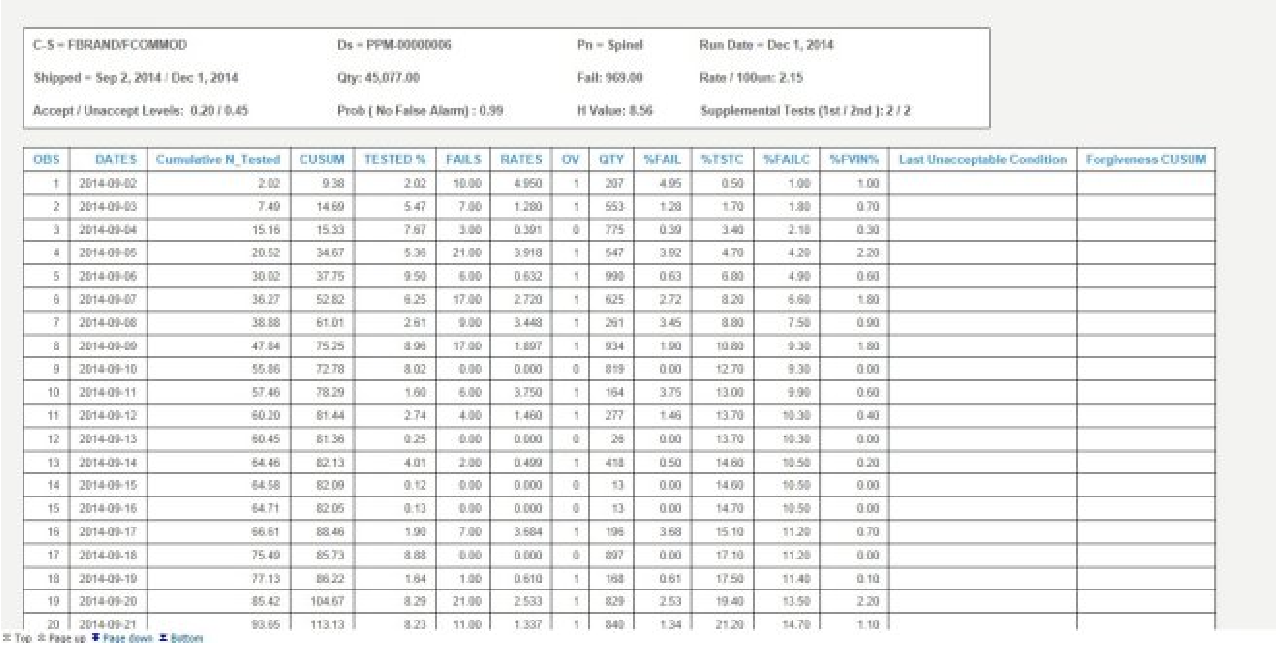


C-S = FBRAND/FCOMMOD, Ds = ECAT, Pn = FIRBDP NOPROC, Run Date = Jan 19, 2015
Shipped = Aug 16, 2014 / Jan 17, 2015, Qty: 1,440.00, Fail: 27.00, Rate / 100un: 1.88

Accept / Unaccept Levels: 0.95 / 1.67, Prob (No False Alarm) : 0.99, Severity: 0.9982

Figure 17. Inspection chart 3

In addition to the above chart the report also shows the summary of the Inspection analysis output.



C-S = FBRAND/FCOMMOD	Ds = PPM-00000006	Pn = Spinel	Run Date = Dec 1, 2014
Shipped = Sep 2, 2014 / Dec 1, 2014	Qty: 45,077.00	Fail: 969.00	Rate / 100un: 2.15
Accept / Unaccept Levels: 0.20 / 0.45	Prob (No False Alarm) : 0.99	H Value: 8.56	Supplemental Tests (1st / 2nd): 2 / 2

OBS	DATES	Cumulative N_Tested	CUSUM	TESTED %	FAILS	RATES	OV	QTY	%FAIL	%TSTC	%FAILC	%FVIN%	Last Unacceptable Condition	Forgiveness CUSUM
1	2014-09-02	2.02	9.38	2.02	10.00	4.950	1	207	4.95	0.50	1.00	1.00		
2	2014-09-03	7.49	14.69	5.47	7.00	1.280	1	553	1.28	1.70	1.80	0.70		
3	2014-09-04	15.16	15.33	7.67	3.00	0.391	0	775	0.39	3.40	2.10	0.30		
4	2014-09-05	20.52	34.67	5.36	21.00	3.918	1	547	3.92	4.70	4.20	2.20		
5	2014-09-06	30.02	37.75	9.50	6.00	0.632	1	990	0.63	6.80	4.90	0.60		
6	2014-09-07	36.27	52.82	6.25	17.00	2.720	1	625	2.72	8.20	6.60	1.80		
7	2014-09-08	38.88	61.01	2.61	9.00	3.448	1	261	3.45	8.80	7.50	0.90		
8	2014-09-09	47.84	75.25	8.96	17.00	1.897	1	934	1.90	10.80	9.30	1.80		
9	2014-09-10	55.86	72.78	8.02	0.00	0.000	0	819	0.00	12.70	9.30	0.00		
10	2014-09-11	57.46	78.29	1.60	6.00	3.750	1	164	3.75	13.00	9.90	0.60		
11	2014-09-12	60.20	81.44	2.74	4.00	1.460	1	277	1.46	13.70	10.30	0.40		
12	2014-09-13	60.45	81.36	0.25	0.00	0.000	0	26	0.00	13.70	10.30	0.00		
13	2014-09-14	64.46	82.13	4.01	2.00	0.499	1	418	0.50	14.60	10.50	0.20		
14	2014-09-15	64.58	82.09	0.12	0.00	0.000	0	13	0.00	14.60	10.50	0.00		
15	2014-09-16	64.71	82.05	0.13	0.00	0.000	0	13	0.00	14.70	10.50	0.00		
16	2014-09-17	66.61	88.46	1.90	7.00	3.684	1	196	3.68	15.10	11.20	0.70		
17	2014-09-18	75.49	85.73	8.88	0.00	0.000	0	897	0.00	17.10	11.20	0.00		
18	2014-09-19	77.13	86.22	1.64	1.00	0.610	1	168	0.61	17.50	11.40	0.10		
19	2014-09-20	85.42	104.67	8.29	21.00	2.533	1	829	2.53	19.40	13.50	2.20		
20	2014-09-21	93.65	113.13	8.23	11.00	1.337	1	840	1.34	21.20	14.70	1.10		

Figure 18. Inspection chart report

Interpreting the Parametric Chart

The first chart is called the Variable value Rate Chart, which is a Statistical Process Control chart. The X axis has the time slice number in the scale. The Y Axis has the variable values in the scale. The orange line graph represents the association of variable value rate against the Vintage number. A thick white line that is parallel to the X axis indicates the target value for the Variable under analysis. A blue dotted line, similar to the Target line, notifies the unacceptable mean or deviation. If the Type of Control is 1, then the Unacceptable deviation appears either above or below the Target line; the position depends on whether the deviation is on the higher side or the lower side of the Target. If the Type of Control is 2, then the unacceptable deviation appears on both upper and lower sides, encasing the Target line. If the line graph crosses over the unacceptable deviation line, the variable value is not meeting the expected standard or guidelines and this may have impact on the process, product, material, location, or resource (any entity) under consideration. This is a reactive mechanism, where measures of remediation can only take place when the first instance when the curve crosses the acceptance level.

The second chart is called the Evidence Chart. The Evidence chart is proprietary to IBM Research. The X axis shares the same scales as the Variable Value Rate Chart. The Y axis scale is Cumulative sum (cusum) of variable value rates. The blue line graph represents the cusum curve that is plotted relating the cusum of variable value rates with the vintage number or time window. The thick white line that is parallel to the X axis is the Threshold of acceptance, which is built on cusum of variable value rates. The line graph has triangle markings once it crosses the threshold line. The first instance where the line crosses the threshold is called the first alarm signal. If the type of control is 1, then there is one threshold line; the line can be above the Target (that is, an upper threshold) or below the Target (that is, a lower threshold). If the Type of control is 2, then there are upper and lower thresholds. If the line graph crosses over a threshold, it represents an alarm condition and the process is out of control.

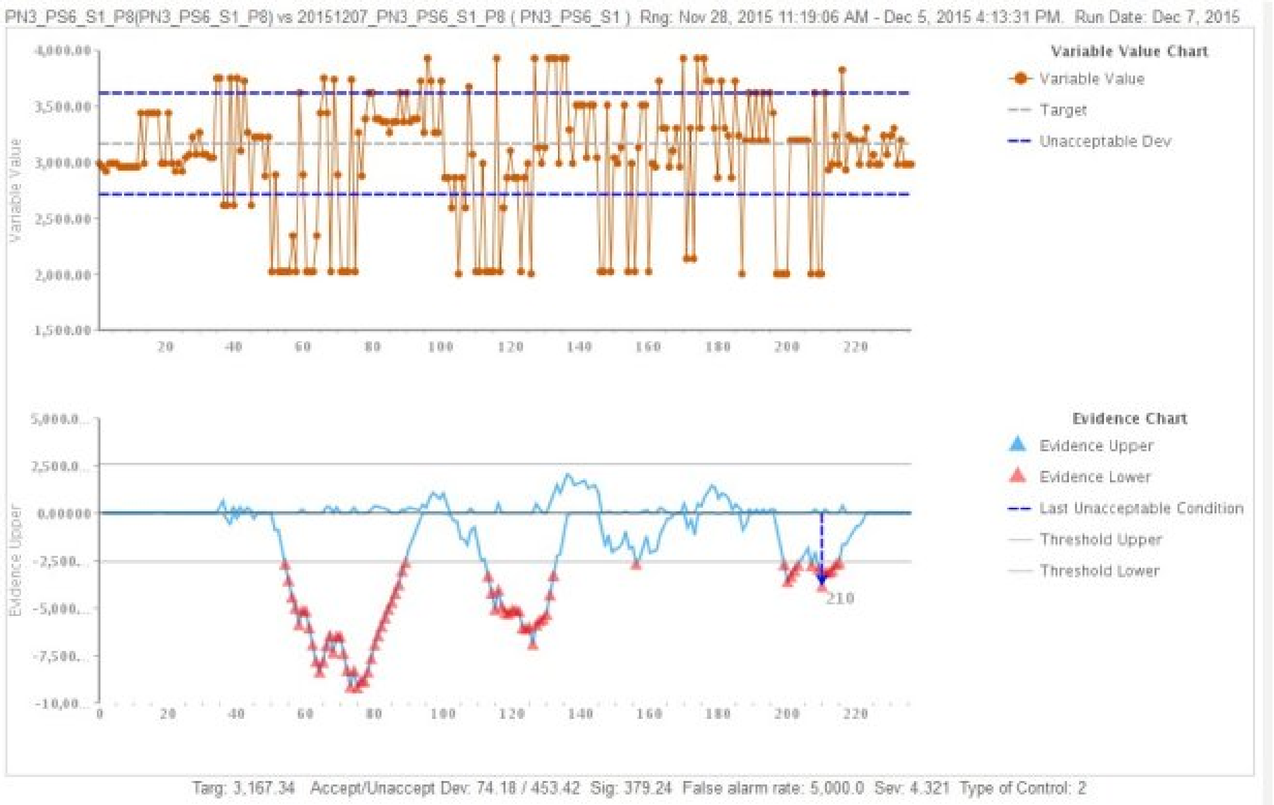


Figure 19. Parametric chart 1

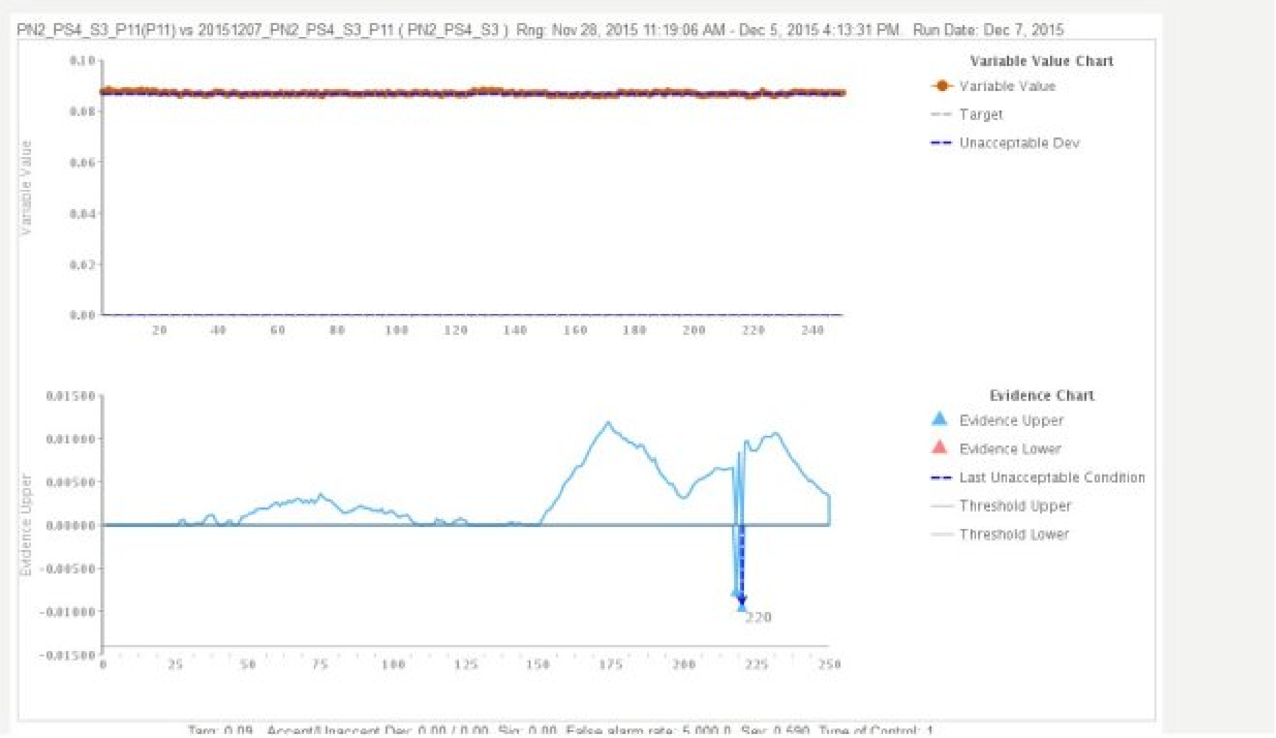
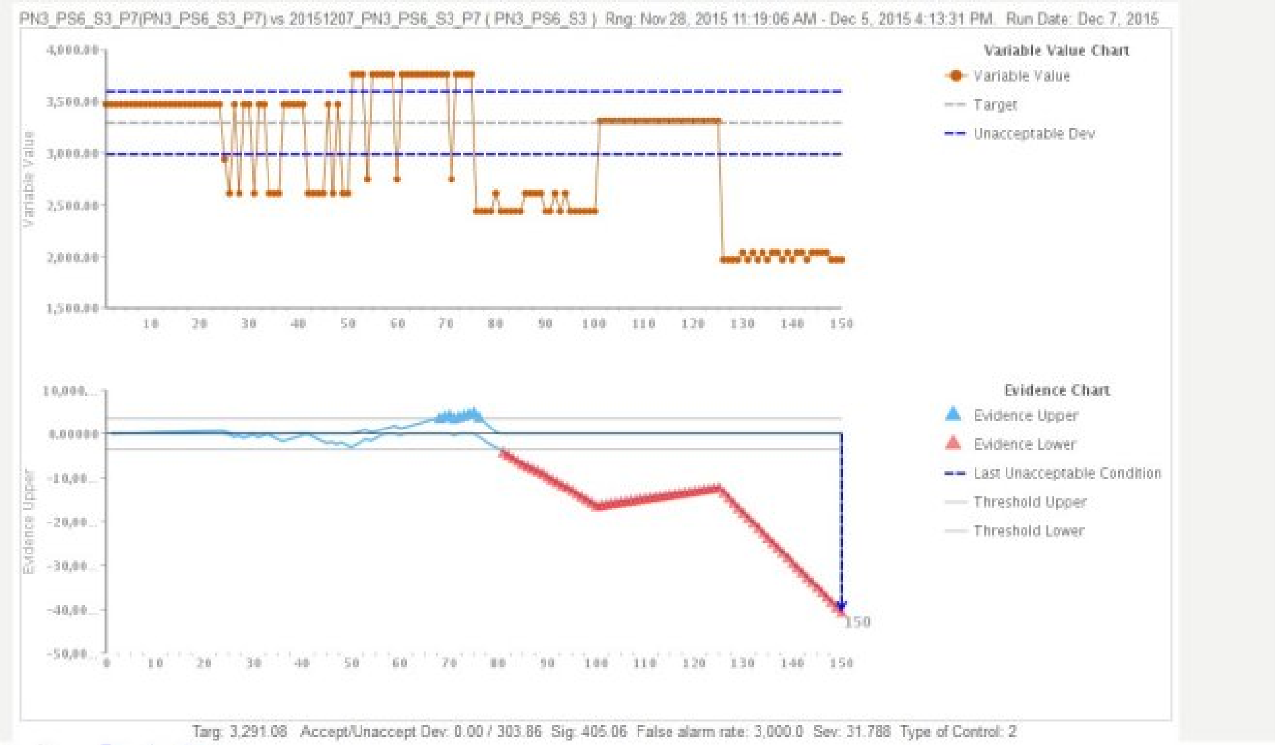


Figure 20. Parametric chart 2



Targ: 3,291.08 Accept/Unaccept Dev: 0.00 / 303.86 Sig: 405.06 False alarm rate: 3,000.0 Sev: 31.788 Type of Control: 2

Figure 21. Parametric chart 3

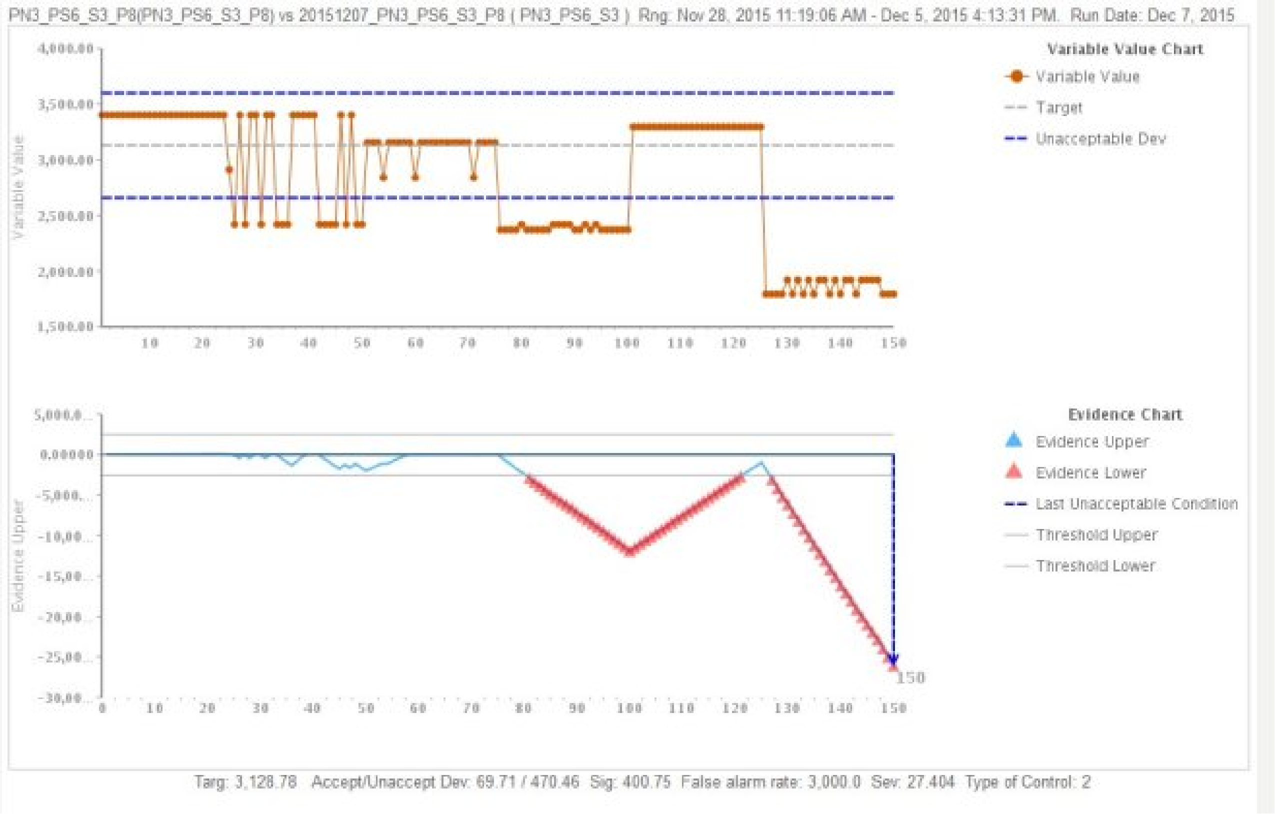
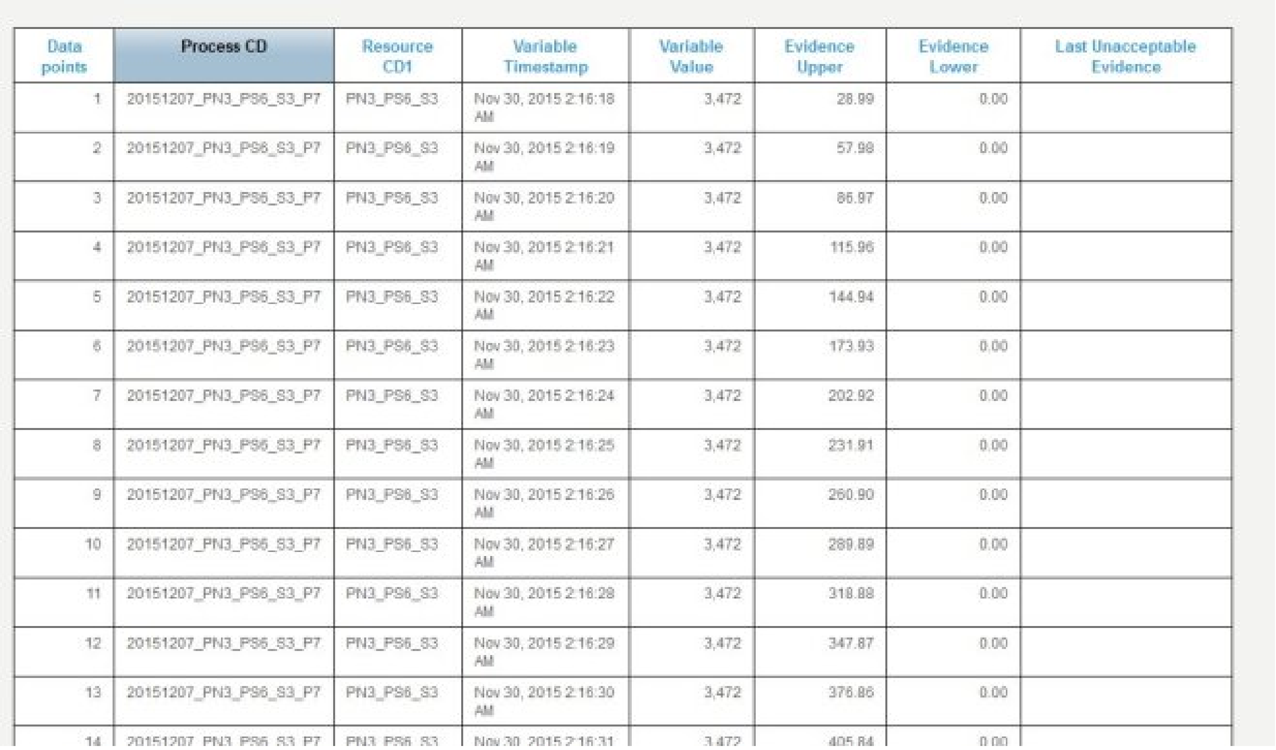


Figure 22. Parametric chart 4

In addition to the above chart the report also shows the summary of the Parametric analysis output.



Data points	Process CD	Resource CD1	Variable Timestamp	Variable Value	Evidence Upper	Evidence Lower	Last Unacceptable Evidence
1	20151207_PN3_PS6_S3_P7	PN3_PS6_S3	Nov 30, 2015 2:16:18 AM	3,472	28.99	0.00	
2	20151207_PN3_PS6_S3_P7	PN3_PS6_S3	Nov 30, 2015 2:16:19 AM	3,472	57.98	0.00	
3	20151207_PN3_PS6_S3_P7	PN3_PS6_S3	Nov 30, 2015 2:16:20 AM	3,472	86.97	0.00	
4	20151207_PN3_PS6_S3_P7	PN3_PS6_S3	Nov 30, 2015 2:16:21 AM	3,472	115.96	0.00	
5	20151207_PN3_PS6_S3_P7	PN3_PS6_S3	Nov 30, 2015 2:16:22 AM	3,472	144.94	0.00	
6	20151207_PN3_PS6_S3_P7	PN3_PS6_S3	Nov 30, 2015 2:16:23 AM	3,472	173.93	0.00	
7	20151207_PN3_PS6_S3_P7	PN3_PS6_S3	Nov 30, 2015 2:16:24 AM	3,472	202.92	0.00	
8	20151207_PN3_PS6_S3_P7	PN3_PS6_S3	Nov 30, 2015 2:16:25 AM	3,472	231.91	0.00	
9	20151207_PN3_PS6_S3_P7	PN3_PS6_S3	Nov 30, 2015 2:16:26 AM	3,472	260.90	0.00	
10	20151207_PN3_PS6_S3_P7	PN3_PS6_S3	Nov 30, 2015 2:16:27 AM	3,472	289.89	0.00	
11	20151207_PN3_PS6_S3_P7	PN3_PS6_S3	Nov 30, 2015 2:16:28 AM	3,472	318.88	0.00	
12	20151207_PN3_PS6_S3_P7	PN3_PS6_S3	Nov 30, 2015 2:16:29 AM	3,472	347.87	0.00	
13	20151207_PN3_PS6_S3_P7	PN3_PS6_S3	Nov 30, 2015 2:16:30 AM	3,472	376.86	0.00	
14	20151207_PN3_PS6_S3_P7	PN3_PS6_S3	Nov 30, 2015 2:16:31	3,472	405.84	0.00	

Figure 23. Parametric analysis output

Appendix C. The Predictive Warranty content pack and artifacts

The Predictive Warranty content pack contains a collection of artifacts, such as database scripts, and XML configuration files. These artifacts support logical model, physical model and orchestrations, and connectors to invoke the algorithm and reports conveying the analysis. A content author can modify this content pack to meet business needs.

At the root of the content pack, there is a file named `solutionconfiguration.xml`. For each level of the logical model hierarchy, you can define associations to content artifacts to load data, run predictions, and visualize results. This file contains a catalog of all artifacts in your solution. For each content artifact, there is a version number and a name, and the categories it belongs to. For example:

```
<solutionDefinitionModel version="1.0"
       path="pmq_models/solution_definition/PMQ_solution_definition.xml"
       id="solutiondefinition" author="IBM"></solutionDefinitionModel>
```

If you change it, increment the version number.

```
<solutionDefinitionModel version="1.1"
       path="pmq_models/solution_definition/PMQ_solution_definition.xml"
       id="solutiondefinition" author="IBM"></solutionDefinitionModel>
```

To delete, remove a line.

Data model

The data model files for Predictive Warranty are `IBMPMQ.sql` and `IBMPMQ_additional.sql`. They are in the `database_scripts` folder in the content pack.

`IBMPMQ.sql`
Contains the definition of physical data model such as master data table, event tables, KPI, and profile tables that are used for Predictive Warranty.

`IBMPMQ_additional.sql`
Contains a stored procedure to initialize the calendar data and to populate a default language and tenant for the solution.

Analytics Solutions Foundation artifacts

Analytics Solutions Foundation enables you to define and manage aggregates and build the orchestration process to feed aggregated data into predictive models.

Solutions created with Analytics Solutions Foundation consume events and make recommendations. They use profiles and key performance indicators to aggregate the events. The aggregations are used to provide scores using predictive models. Decision management makes recommendations based on the values of the scores.

Maintenance Streams

The `logical_model` folder contains the following XML files:

BaseLogicalModel.xml
Contains the common data structures that are required for all of the business imperatives (predictive quality, predictive warranty, predictive maintenance) for defining and loading master data.

BaseQualityLogicalModel.xml
Contains the data structures that are common between the Quality Early Warning System use cases. (Inspection, Parametric and Warranty). The data structures help you to define a structure for loading the master data into the solution data store for the Predictive Quality business imperative.

WarrantyLogicalModel.xml
Contains the definitions for entities and events which load data for Predictive Warranty. The event sub types are `SalesEvent` and `WarrantyEvent`.

The `orchestration` folder contains the following XML files:

PMQ_Orchestration_definition_warranty.xml
Defines rules about how event or fact data is loaded into the solution data store.

PMQ_Orchestration_definition_warranty_job.xml
Defines the steps to invoke lifetime analysis. An SPSS stream is invoked which does the data preparation for the algorithm and then the algorithm for lifetime analysis is invoked.

The `solution_definition` folder contains `PMQ_Solution_definition.xml`. This file defines the table and object structures that define the database.

IBM SPSS artifacts

IBM SPSS streams are used in Predictive Warranty to transform event data and master data to create a table structure. The table structure is input for triggering the lifetime analysis algorithm.

The following streams are in the `predictive` folder:

IBMPMQ_QEWSL_SALES.str
Used to prepare the SALES related data for analysis. In the SALES use case, the warranty start period is the sales date from the event data.

IBMPMQ_QEWSL_WARR.str
Used to prepare the PROD and MFG data for analysis. In MFG and PROD, the warranty start period is set to either the product produced date or the resource assembled date.

IBM Cognos Business Intelligence artifacts

IBM Cognos Business Intelligence on Cloud is a suite that provides tools to create reports and dashboards and build interactive analyses. A content author can develop new BI views and add them to the deployment archive provided in the default content pack.

Warranty report

The warranty report monitors information about lifetimes of systems and individuals. You can run the warranty report by selecting a run date and the product grain. The warranty report contains the following charts:

SPC chart
Plots the variations with respect to time.

Evidence chart
Enables the business community with the early warning detections on the life of the product and its wear out rate.

Initial configuration files

Metadata in the form of .csv files is used to create the configuration tables that are used by IBM Predictive Solutions Foundation on Cloud. Configuration tables can be modified to suit business needs. The .csv files defining the configuration tables can be found in the `source_connectors\config_data_sets` folder.

Configuration table artifacts

The configuration table artifacts are described in the following table:

Table 17. Configuration table artifacts

File name	Description
`SourceSystem.csv`	Defines where the master or event data is streamed from, such as MAXIMO (enterprise asset management software) or SENSOR (if the source of the fact data is sensors).
`ValueType.csv`	Defines the types of values that the event data can bring in (Actual, Forecast, or Planned).

Predictive Warranty sample data

Business scenario for Lifetime or Warranty analysis

The warranty data and analytics can be used in a manufacturing company in several ways. Some of the common uses are identifying conditions leading to accelerated replacement or wear of parts (process, vendorquality, parts quality, service condition), warranty pricing analytics (including extended warranty pricing), strategic vendor identification, and so on.

All other use cases are dependent upon primary warranty use case. For example, to implement warranty pricing analytics, you first must understand the factors that affect the wear and replacement rates of a given part under warranty.

If a company can identify the points of occurrence of accelerated wear earlier, it can realize savings by not only fixing the causes earlier, but also preventing parts that may demonstrate similar phenomena from being sold and thereby leading to more claims and related losses.

IBM Predictive Warranty is an implementation of the IBM QEWSL (Quality Early Warning System - for Lifetime applications) algorithm, which has proven capabilities to give early warning signals of accelerated wear and replacement for a part, with minimal false alarms.

Predictive Warranty uses the core QEWSL algorithm in three use cases: Sales, Production, and Manufacturing. These use cases differ in terms of data loading and SPSS data transformation. The operational and other steps are common to all of the use cases.

SALES Use Case

This use case is useful in identifying the variation in replacement and wear rates while they are aggregated on their respective sales date. The sales date might signify different in-service conditions, atypical to a given pattern of climatic differences, or they might represent sales to a common customer, or other similar occurrences that may be linked to the date/ period of their sales.

For example, for parts carrying a common one year warranty, if they were suffering brittle failure under cold climates at a given location, the parts which went in service during winters will have a rapid wear during their initial service months, followed by a delayed wear during later service at the end of their warranty period. The case may be reversed for the parts that were sold during summers. These variations will, in turn, affect their wear rates and weighted replacement rates, which might be captured very early by the QEWSL algorithm.

PROD (Production) use case

This use case is useful in identifying the variation in replacement and wear rates of a given part type fitted in a resource while they are aggregated on the part's respective production date. The production date based anomaly similarity may in turn correspond to the quality of parts, or some process related issues during the production.

For example, if there are some batches of a part produced on a given date, or in a similar period, then the resources in which these parts were fitted may suffer rapid wear or replacements for these parts, which may not be related or identified by the resource manufacturing or assembly or sales date. Once such occurrences are using the production use case of IBM PMQ warranty feature, such phenomena might be easier and faster to identify and understand.

MFG (Manufacturing) use case

This use case is useful in identifying the variation in replacement and wear rates of a given part type fitted in a resource while they are aggregated on the resource's respective manufacturing or assembly date. The manufacturing date based anomaly similarity may in-turn correspond to compromised manufacturing batches or assembly issues due to some reasons on a given date or period.

For example, if there are some manufactured or assembled batches of a resource whose parts fail prematurely due to process issues on the manufacturing lot or assembly line, it may be easier and faster to identify and understand such issues using the manufacturing use case.

Input Files for Predictive Warranty

There are three major types of input files:

- Configuration files
  - Logical model files
  - Orchestration files
  - Solution definition files
- Master CSV files

- Event CSV files

Configuration files

The Warranty logical model xml file (in the logicalmodel folder) contains the way in which the CSV files must be structured. This xml file defines the structure for each Master data entity, event data entity, and the triggering mechanism for the Warranty use case. Master and Event data entities are mapped to the appropriate Master table that is defined in the Predictive Warranty datamodel.

For example, the master entity Product (of the Warranty use case) is defined as follows:

```
<entity code="Product" description="Represents a product" displayName="Product" extendable="false"
    <instanceTableMap instanceTableCode="MASTER_PRODUCT" />
    <attribute code="ProductCode" displayName="Product Code" columnCode="PRODUCT_CD" dataType="str
    <attribute code="ProductName" displayName="Product Name" columnCode="PRODUCT_NAME" dataType="s
    <attribute code="ProductTypeCode" displayName="Product Type Code" columnCode="PRODUCT_TYPE_CD"
    <attribute code="ProductTypeName" displayName="Product Type Name" columnCode="PRODUCT_TYPE_NAM
    <attribute code="IsActive" displayName="Is Active" columnCode="IS_ACTIVE" dataType="boolean" i
    <selfReference columnCode="PARENT_PRODUCT_ID">
      <attribute code="ParentProductCode" dataType="string" description="Parent Product Code" disp
      <attribute code="ParentProductTypeCode" dataType="string" description="Parent Product Type C
    </selfReference>
</entity>
```

The columns for the master entity Product appear as attributes and those cyclic references or self references are defined for the product itself. The mapping to the table MASTER_PRODUCT is in the instanceTableMap tag.

Parameters (ie LAM0, LAM1, CW0, CW1, PROB0 and PROBW0) are under Master, where an entity called master_parameter_grain table is defined, which provides a grain identity for a unique combination of location, product, production batch, resource, process, material and measurement type. Measurement type is tightly coupled to event type, which means that when we define an event type we define measurement type as its attributes.

The master_parameter table contains the parameters as such - LAM0, LAM1, etc. The master parameter and parameter grain are joined in a parameter value table and its value respective to each measurement type par event type is loaded here.

The following example shows the definition of the parameter grain in the logical model, and the parameters that are used for the Warranty use case:

```
<entity code="Parameter" description="Parameter" displayName="Parameter" extendable="true" id="" v
        <typeTableMap typeTableCode="MASTER_MODEL_TYPE" typeCodeColumnRef="MODEL_TYPE_CD" typePare
        <attributeTableMap attributeTableCode="MASTER_PARAMETER" attributeCodeColumnRef="PARAMETER
        <instanceTableMap instanceTableCode="MASTER_PARAMETER_GRAIN"/>
        <attributeValueTableMap attributeValueTableCode="MASTER_PARAMETER_VALUE" attributeCodeColu
<reference entityRef="Location" isRequired="true" columnCode="LOCATION_ID" isKey="true">
        <attribute code="Location" description="Location" displayName="Location" dataType="string"
        </reference>
                <reference entityRef="Resource" isRequired="true" columnCode="RESOURCE_ID" isKey="
                      <attribute code="ResourceCd1" description="Resource Code 1" displayName="Res
                      <attribute code="ResourceCd2" description="Resource Code 2" displayName="Res
                </reference>
                <reference entityRef="Product" isRequired="true" columnCode="PRODUCT_ID" isKey="tr
                      <attribute code="ProductCode" description="Product Code" displayName="Produc
                      <attribute code="ProductTypeCode" description="Product Type Code" displayNam
                </reference>
                <reference entityRef="Process" isRequired="true" columnCode="PROCESS_ID" isKey="tr
                      <attribute code="ProcessCode" description="Process Code" displayName="Proces
```

```
               </reference>
              <reference entityRef="ProductionBatch" isRequired="true" columnCode="PRODUCTION_BATCH_
                    <attribute code="ProductionBatchCode" description="Production Batch Code" disp
              </reference>
              <reference entityRef="Material" isRequired="true" columnCode="MATERIAL_ID" isKey="tru
                     <attribute code="MaterialCode" description="Material Code" displayName="Mater
              </reference>
              <reference entityRef="MeasurementType" isRequired="true" columnCode="MEASUREMENT_TYPE_
                    <attribute code="MeasurementTypeCode" description="Measurement Type Code" disp
                     <attribute dataType="string" code="EventTypeCode" description="Event Type Cod
              </reference>
</entity>
```

The following xml definition extends the Parameter definition. The CSV file for Warranty parameters is defined such that the first set of columns carries all the master entity references for defining a parameter grain, and the next extended part carries the parameters (as attributes) as column names (LAM0, LAM1, PROB0). This defines a parameter grain and parameters to the grain in one row of the CSV file.

```
<entitySubType code="Warranty" description="Warranty" displayName="Warranty" extends="Parameter" id="
    <attribute code="LAM0" displayName="LAM 0" dataType="double" description="LAM 0" isRequired="tru
    <attribute code="LAM1" displayName="LAM 1" dataType="double" description="LAM 1" isRequired="tru
    <attribute code="PROB0" displayName="PROB 0" dataType="double" description="PROB 0" isRequired="
    <attribute code="CW0" displayName="CW 0" dataType="double" description="CW 0" isRequired="true"/
    <attribute code="CW1" displayName="CW 1" dataType="double" description="CW 1" isRequired="true"/
    <attribute code="PROBW0" displayName="PROB W0" dataType="double" description="PROB W0" isRequire
  </entitySubType>
```

Event entities are defined in a similar way. The master reference grains under QualityEvent and this entity type are extended by SalesEvent and WarrantyEvent. The SalesEvent carries the attribute of WarrantyPeriod (in months), while the WarrantyEvent carries the attribute of WarrantyIndicator (a measurement flag which says whether the fact data is covered under warranty or not). The CSV for these two event types has the QualityEvent attribute, which covers the multi-grain entities and the measurement or observations respective to that sub entity type.

SalesEvent logical model structure:

```
<eventSubType code="SalesEvent" description="Represents a sales event in PMQ" displayName="Sales Eve
 <attribute code="WarrantyPeriod" displayName="Warranty Period" dataType="double" description="Warra
  <typePropertyValue propertyRef="UnitOfMeasure" value="months"/>
 </attribute>
</eventSubType>
```

WarrantyEvent logical model structure:

```
<eventSubType code="WarrantyEvent" description="Represents a warranty event in PMQ" displayName="War
 <attribute code="WarrantyIndicator" displayName="Warranty Indicator" dataType="string" description="
</eventSubType>
```

Orchestration files (in the orchestration folder) are also important to configuration. There are two orchestration files: one for handling Warranty related event data persistence to the Predictive Warranty Event store; the other one for triggering Warranty analysis.

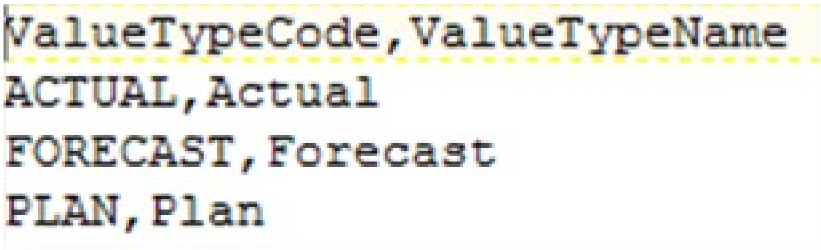
The final configuration file is the solution definition xml file. This file defines all the table structures that are part of the Predictive Quality and Predictive Warranty data store.

Master CSV files

The Master CSV files carry all the master data set or entity data set whose various observations or measurements are recorded and analyzed. For the sake of Predictive Warranty, the following are the required Master data sets that must be loaded before any fact data is loaded.

The list of CSV files to be loaded in sequence is:

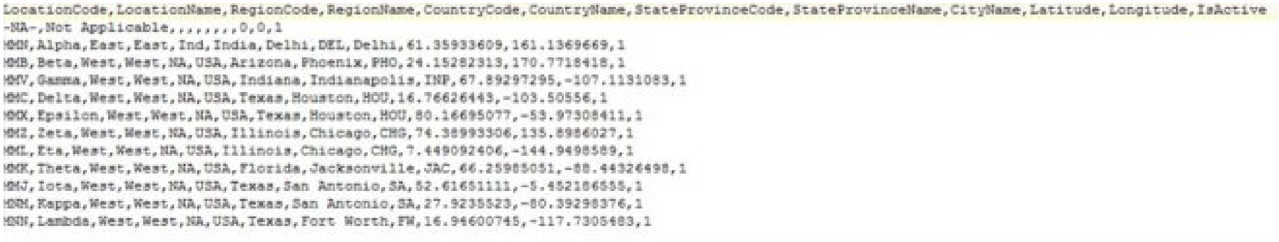
1. **Master_Value_type** - The Value type offers only three values: ACTUAL, PLAN, and FORECAST. Normally, the data associated with inspection or parametric events are only ACTUAL.



```
ValueTypeCode,ValueTypeName
ACTUAL,Actual
FORECAST,Forecast
PLAN,Plan
```

Figure 24. Master_Value_type

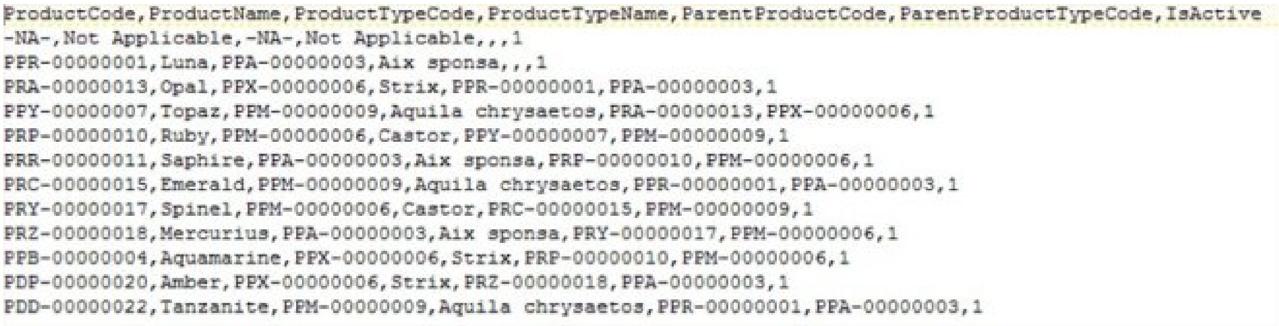
2. **Master_Location** - The Location data holds information that is specific to the geography of the location where the event is produced, or the resource that produces the events.



```
LocationCode,LocationName,RegionCode,RegionName,CountryCode,CountryName,StateProvinceCode,StateProvinceName,CityName,Latitude,Longitude,IsActive
-NA-,Not Applicable,,,,,,,,0,0,1
MMN,Alpha,East,East,Ind,India,Delhi,DEL,Delhi,61.35933609,161.1369669,1
MMB,Beta,West,West,NA,USA,Arizona,Phoenix,PHO,24.15282313,170.7718418,1
MMV,Gamma,West,West,NA,USA,Indiana,Indianapolis,INP,67.89297295,-107.1131083,1
MMC,Delta,West,West,NA,USA,Texas,Houston,HOU,16.76626443,-103.50556,1
MMX,Epsilon,West,West,NA,USA,Texas,Houston,HOU,80.16695077,-53.97308411,1
MMZ,Zeta,West,West,NA,USA,Illinois,Chicago,CHG,74.38993306,135.8986027,1
MML,Eta,West,West,NA,USA,Illinois,Chicago,CHG,7.449092406,-144.9498589,1
MMK,Theta,West,West,NA,USA,Florida,Jacksonville,JAC,66.25985051,-88.44326498,1
MMJ,Iota,West,West,NA,USA,Texas,San Antonio,SA,52.61651111,-5.452186555,1
MMM,Kappa,West,West,NA,USA,Texas,San Antonio,SA,27.9235523,-80.39298376,1
MNN,Lambda,West,West,NA,USA,Texas,Fort Worth,FW,16.94600745,-117.7305483,1
```

Figure 25. Master_Location

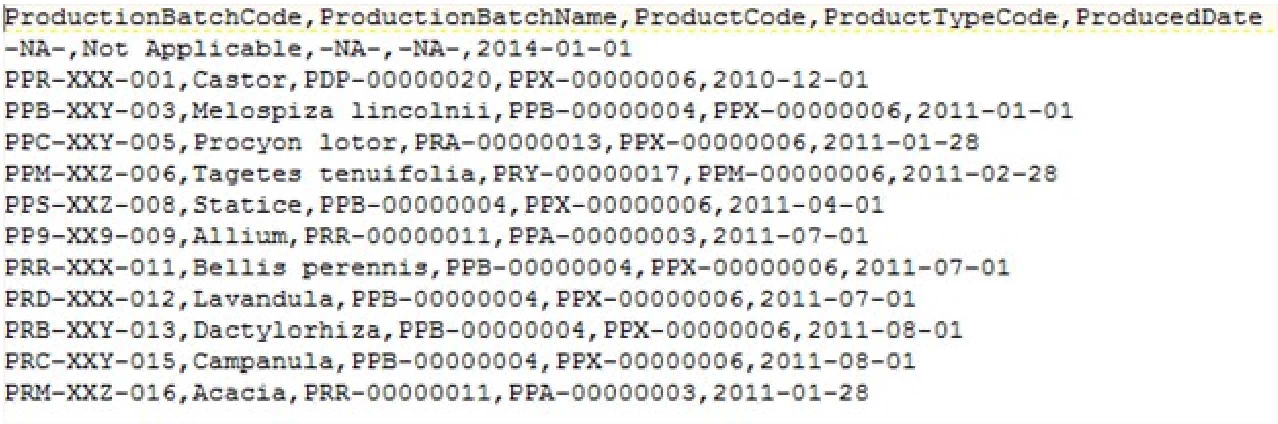
3. **Master product** - This table forms the core data for the warranty use case. This table stores product-related information along with the information of what product_type it is.



```
ProductCode,ProductName,ProductTypeCode,ProductTypeName,ParentProductCode,ParentProductTypeCode,IsActive
-NA-,Not Applicable,-NA-,Not Applicable,,,1
PPR-00000001,Luna,PPA-00000003,Aix sponsa,,,1
PRA-00000013,Opal,PPX-00000006,Strix,PPR-00000001,PPA-00000003,1
PPY-00000007,Topaz,PPM-00000009,Aquila chrysaetos,PRA-00000013,PPX-00000006,1
PRP-00000010,Ruby,PPM-00000006,Castor,PPY-00000007,PPM-00000009,1
PRR-00000011,Saphire,PPA-00000003,Aix sponsa,PRP-00000010,PPM-00000006,1
PRC-00000015,Emerald,PPM-00000009,Aquila chrysaetos,PPR-00000001,PPA-00000003,1
PRY-00000017,Spinel,PPM-00000006,Castor,PRC-00000015,PPM-00000009,1
PRZ-00000018,Mercurius,PPA-00000003,Aix sponsa,PRY-00000017,PPM-00000006,1
PPB-00000004,Aquamarine,PPX-00000006,Strix,PRP-00000010,PPM-00000006,1
PDP-00000020,Amber,PPX-00000006,Strix,PRZ-00000018,PPA-00000003,1
PDD-00000022,Tanzanite,PPM-00000009,Aquila chrysaetos,PPR-00000001,PPA-00000003,1
```

Figure 26. Master_Product

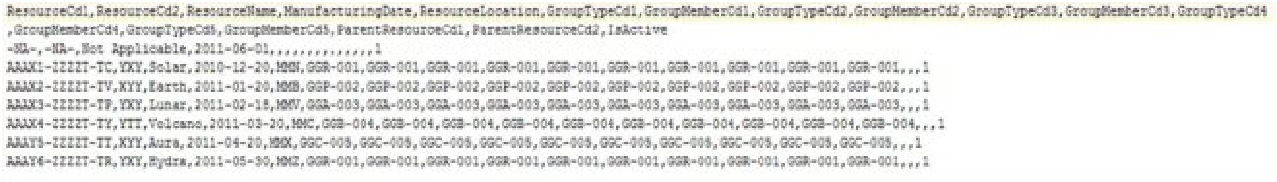
4. **Master_ProductionBatch** - This table maintains information about each production batch that is used to produce the desired products. It maintains details like which product is produced, at what date it is produced, and the batch information.



```
ProductionBatchCode,ProductionBatchName,ProductCode,ProductTypeCode,ProducedDate
-NA-,Not Applicable,-NA-,-NA-,2014-01-01
PPR-XXX-001,Castor,PDP-00000020,PPX-00000006,2010-12-01
PPB-XXY-003,Melospiza lincolnii,PPB-00000004,PPX-00000006,2011-01-01
PPC-XXY-005,Procyon lotor,PRA-00000013,PPX-00000006,2011-01-28
PPM-XXZ-006,Tagetes tenuifolia,PRY-00000017,PPM-00000006,2011-02-28
PPS-XXZ-008,Statice,PPB-00000004,PPX-00000006,2011-04-01
PP9-XX9-009,Allium,PRR-00000011,PPA-00000003,2011-07-01
PRR-XXX-011,Bellis perennis,PPB-00000004,PPX-00000006,2011-07-01
PRD-XXX-012,Lavandula,PPB-00000004,PPX-00000006,2011-07-01
PRB-XXY-013,Dactylorhiza,PPB-00000004,PPX-00000006,2011-08-01
PRC-XXY-015,Campanula,PPB-00000004,PPX-00000006,2011-08-01
PRM-XXZ-016,Acacia,PRR-00000011,PPA-00000003,2011-01-28
```

Figure 27. Master production batch

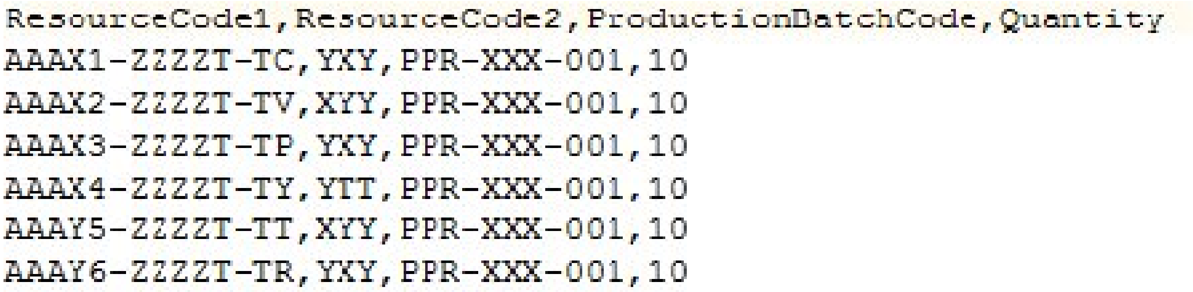
5. **Master Resource** - Master Resource must be loaded if you have to carry out a granular analysis of warranty use case. It stores the resource information and the date on which the resource was assembled or manufactured, the MFG use case of warranty.



```
ResourceCd1,ResourceCd2,ResourceName,ManufacturingDate,ResourceLocation,GroupTypeCd1,GroupMemberCd1,GroupTypeCd2,GroupMemberCd2,GroupTypeCd3,GroupMemberCd3,GroupTypeCd4
,GroupMemberCd4,GroupTypeCd5,GroupMemberCd5,ParentResourceCd1,ParentResourceCd2,IsActive
-NA-,-NA-,Not Applicable,2011-06-01,,,,,,,,,,,,,,1
AAAX1-ZZZZT-TC,YXY,Solar,2010-12-20,MMN,GGR-001,GGR-001,GGR-001,GGR-001,GGR-001,GGR-001,GGR-001,GGR-001,GGR-001,GGR-001,,,1
AAAX2-ZZZZT-TV,XYY,Earth,2011-01-20,MMB,GGP-002,GGP-002,GGP-002,GGP-002,GGP-002,GGP-002,GGP-002,GGP-002,GGP-002,GGP-002,,,1
AAAX3-ZZZZT-TP,YXY,Lunar,2011-02-18,MMV,GGA-003,GGA-003,GGA-003,GGA-003,GGA-003,GGA-003,GGA-003,GGA-003,GGA-003,GGA-003,,,1
AAAX4-ZZZZT-TY,YTT,Volcano,2011-03-20,MMC,GGB-004,GGB-004,GGB-004,GGB-004,GGB-004,GGB-004,GGB-004,GGB-004,GGB-004,GGB-004,,,1
AAAY5-ZZZZT-TT,XYY,Aura,2011-04-20,MMX,GGC-005,GGC-005,GGC-005,GGC-005,GGC-005,GGC-005,GGC-005,GGC-005,GGC-005,GGC-005,,,1
AAAY6-ZZZZT-TR,YXY,Hydra,2011-05-30,MMZ,GGR-001,GGR-001,GGR-001,GGR-001,GGR-001,GGR-001,GGR-001,GGR-001,GGR-001,GGR-001,,,1
```

Figure 28. Master resource

6. **Master Resource Production Batch** - In the lifetime or warranty analysis, this table maintains the ratio of how many items or products from a particular production batch participated in the resource. g_master_resource_production_batch.jpg

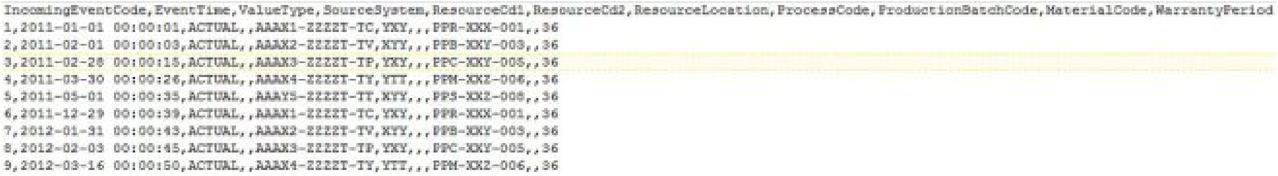


```
ResourceCode1,ResourceCode2,ProductionBatchCode,Quantity
AAAX1-ZZZZT-TC,YXY,PPR-XXX-001,10
AAAX2-ZZZZT-TV,XYY,PPR-XXX-001,10
AAAX3-ZZZZT-TP,YXY,PPR-XXX-001,10
AAAX4-ZZZZT-TY,YTT,PPR-XXX-001,10
AAAY5-ZZZZT-TT,XYY,PPR-XXX-001,10
AAAY6-ZZZZT-TR,YXY,PPR-XXX-001,10
```

Figure 29. Master resource production batch

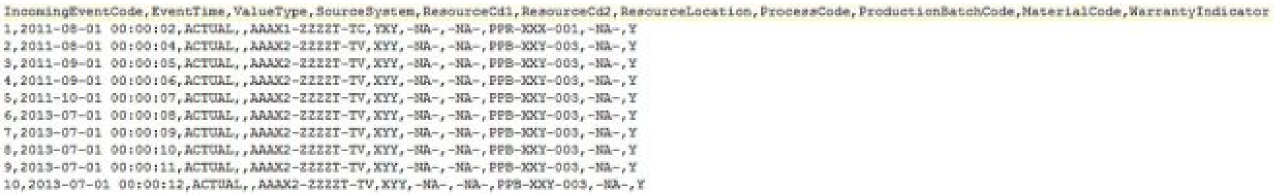
Event CSV files

The event csv files carry contain the fact data of Warranty analysis. Every time a resource is sold, that inventory is loaded through the SalesEvent event type, while every time a part is replaced it is loaded through WarrantyEvent event type.



```
IncomingEventCode,EventTime,ValueType,SourceSystem,ResourceCd1,ResourceCd2,ResourceLocation,ProcessCode,ProductionBatchCode,MaterialCode,WarrantyPeriod
1,2011-01-01 00:00:01,ACTUAL,,AAAX1-ZZZZT-TC,YXY,,,PPR-XXX-001,,36
2,2011-02-01 00:00:03,ACTUAL,,AAAX2-ZZZZT-TV,XYY,,,PPB-XXY-003,,36
3,2011-02-28 00:00:15,ACTUAL,,AAAX3-ZZZZT-TP,YXY,,,PPC-XXY-005,,36
4,2011-03-30 00:00:26,ACTUAL,,AAAX4-ZZZZT-TY,YTT,,,PPM-XXZ-006,,36
5,2011-05-01 00:00:35,ACTUAL,,AAAY5-ZZZZT-TT,XYY,,,PPS-XXZ-008,,36
6,2011-12-29 00:00:39,ACTUAL,,AAAX1-ZZZZT-TC,YXY,,,PPR-XXX-001,,36
7,2012-01-31 00:00:43,ACTUAL,,AAAX2-ZZZZT-TV,XYY,,,PPB-XXY-003,,36
8,2012-02-03 00:00:45,ACTUAL,,AAAX3-ZZZZT-TP,YXY,,,PPC-XXY-005,,36
9,2012-03-16 00:00:50,ACTUAL,,AAAX4-ZZZZT-TY,YTT,,,PPM-XXZ-006,,36
```

Figure 30. Sales event



```
IncomingEventCode,EventTime,ValueType,SourceSystem,ResourceCd1,ResourceCd2,ResourceLocation,ProcessCode,ProductionBatchCode,MaterialCode,WarrantyIndicator
1,2011-08-01 00:00:02,ACTUAL,,AAAX1-ZZZZT-TC,YXY,-NA-,-NA-,PPR-XXX-001,-NA-,Y
2,2011-08-01 00:00:04,ACTUAL,,AAAX2-ZZZZT-TV,XYY,-NA-,-NA-,PPB-XXY-003,-NA-,Y
3,2011-09-01 00:00:05,ACTUAL,,AAAX2-ZZZZT-TV,XYY,-NA-,-NA-,PPB-XXY-003,-NA-,Y
4,2011-09-01 00:00:06,ACTUAL,,AAAX2-ZZZZT-TV,XYY,-NA-,-NA-,PPB-XXY-003,-NA-,Y
5,2011-10-01 00:00:07,ACTUAL,,AAAX2-ZZZZT-TV,XYY,-NA-,-NA-,PPB-XXY-003,-NA-,Y
6,2013-07-01 00:00:08,ACTUAL,,AAAX2-ZZZZT-TV,XYY,-NA-,-NA-,PPB-XXY-003,-NA-,Y
7,2013-07-01 00:00:09,ACTUAL,,AAAX2-ZZZZT-TV,XYY,-NA-,-NA-,PPB-XXY-003,-NA-,Y
8,2013-07-01 00:00:10,ACTUAL,,AAAX2-ZZZZT-TV,XYY,-NA-,-NA-,PPB-XXY-003,-NA-,Y
9,2013-07-01 00:00:11,ACTUAL,,AAAX2-ZZZZT-TV,XYY,-NA-,-NA-,PPB-XXY-003,-NA-,Y
10,2013-07-01 00:00:12,ACTUAL,,AAAX2-ZZZZT-TV,XYY,-NA-,-NA-,PPB-XXY-003,-NA-,Y
```

Figure 31. Warranty event

Arguments passed while triggering the Warranty Analysis

Warranty Analysis is triggered with the following set of arguments:

1. WARRANTY_RUNDATE – This is the date up to which to process information in the subusecase. The value can be today's date or a prior date.
2. WARRANTY_SUBUSECASE – The allowed sub use case values are MFG (for Manufacturing), PROD (for Production use case), or SALES (the use case where SALES date becomes the warranty startdate).

Interpreting the Warranty charts

There are two charts shown by the reports.

The first chart is called the Replacement / Wearout Rate Chart or a Statistical Process Control chart. This chart has a dual-scale X axis. The bottom scale is the Vintage number. The top scale is the cumulative quantity that is tested. The Y axis also has a dual scale. The scale on the left side shows the replacement rate per 100 units; the scale on the right side shows the monthly wearout rate. The orange line graph represents the association of replacement rate against the Vintage number or the tested quantity. The pink dotted line graph represents the association of wearout against the vintage number or tested quantity. The white dotted line that is parallel to the X axis is the acceptable mean of replacement. As per statistical norms, whenever the line graph of replacement rate climbs over the acceptable mean of replacements, it signifies that the quality of the product or the entity under consideration is going out the accepted tolerance level. The same applies to Wear out, but the acceptance level is not plotted. This is a reactive mechanism, where measures of remediation can only take place at the first instance when the curve crosses the acceptance level.

The second chart is called the Evidence Chart. The Evidence chart is proprietary to IBM Research. In the Evidence chart, the X axis shares the same scales as SPC charts. The Y axis scale is Cumulative sum (cusum) of replacements. The blue line graph represents the cusum curve that is plotted relating the cusum of replacement rates with the vintage number or the tested quantity. The thick white line that is parallel to the X axis is the Threshold of acceptance, which is built on cusum of failure rates. The line graph has triangle markings once it crosses the threshold line. The first instance where the line crosses the threshold is called the first alarm signal. On the right side of the chart there is a blue dotted vertical line parallel to the Y axis. This line denotes the highest unacceptable level that the vintage has reached. The gap in the X axis between the last vintage to this highest unacceptable level is called the RCUN Value. After the curve reaches the highest unacceptable condition, the curve descends down and the point of descent is called the forgiveness factor. The forgiveness factor provides a level where, based on the current trend, it would factor out whether the curve returns to normalcy. Similarly, the pink line graph depicts the cusum of the wear out rates. Here, instead of triangles there are thick dots that signify that the curve has crossed the Threshold of Wear out. The Threshold of Wear out is drawn as a pink dotted line parallel to the X Axis.

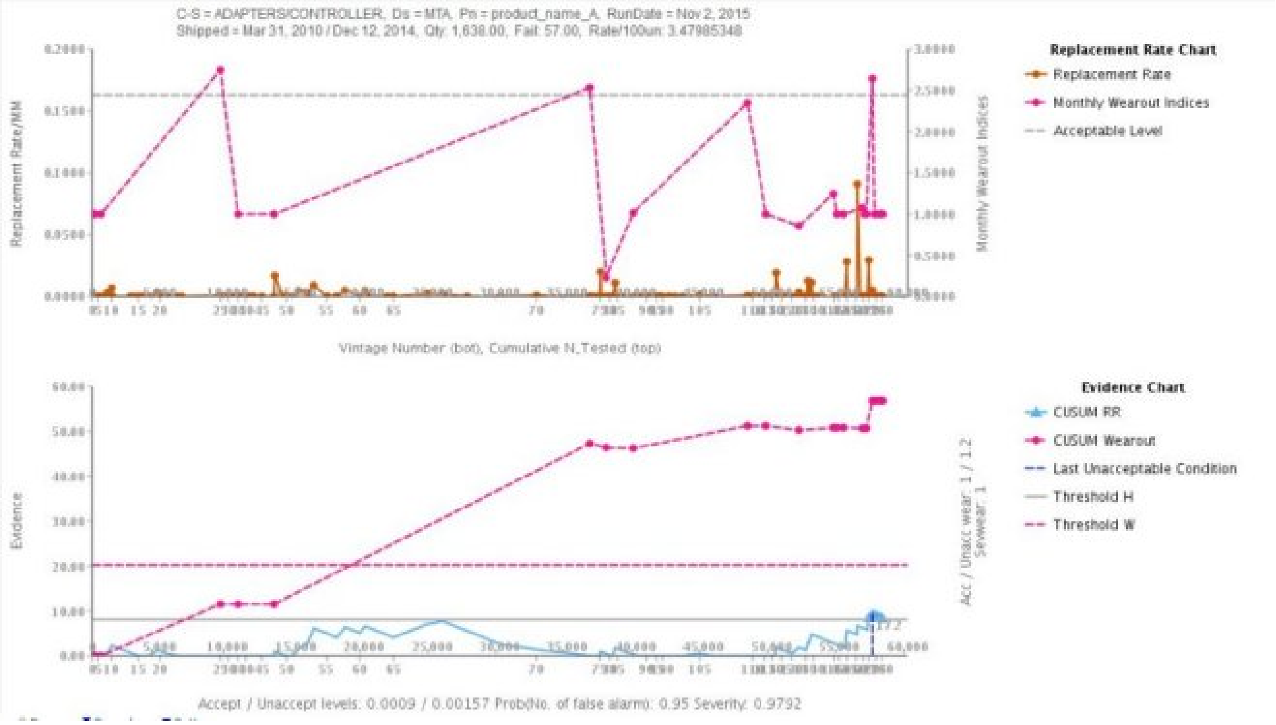


Figure 32. Warranty chart 1

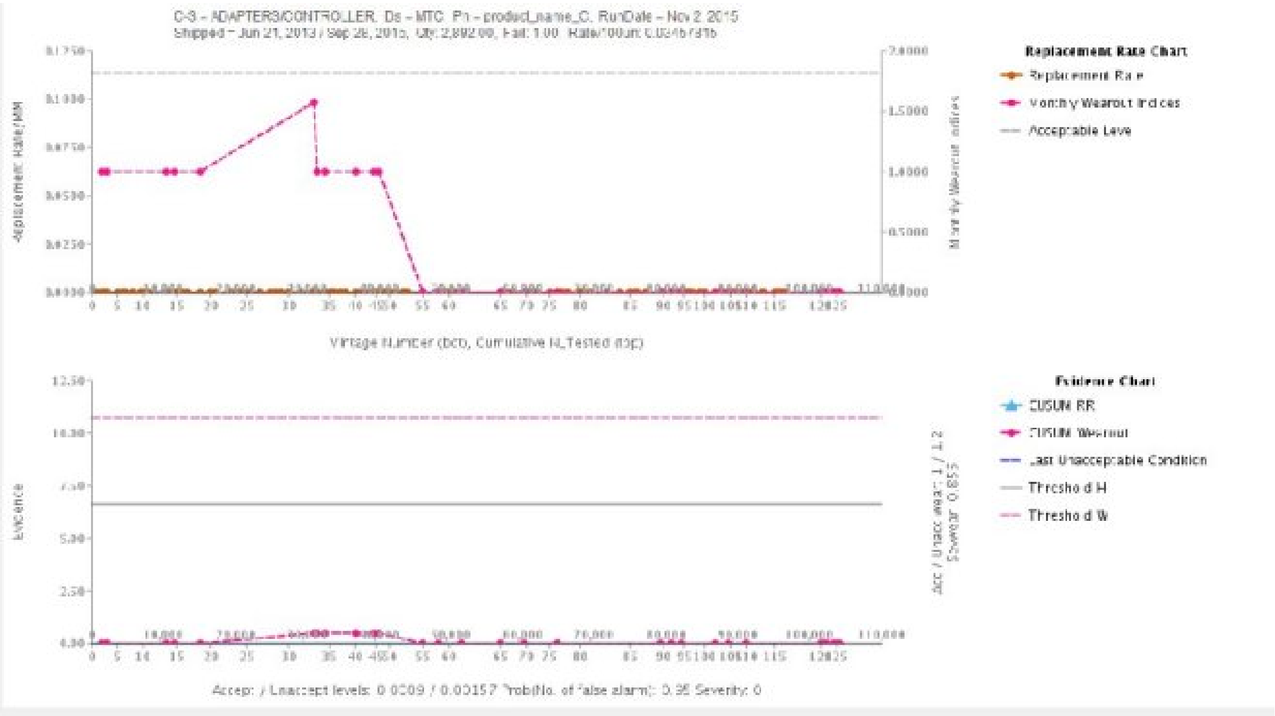
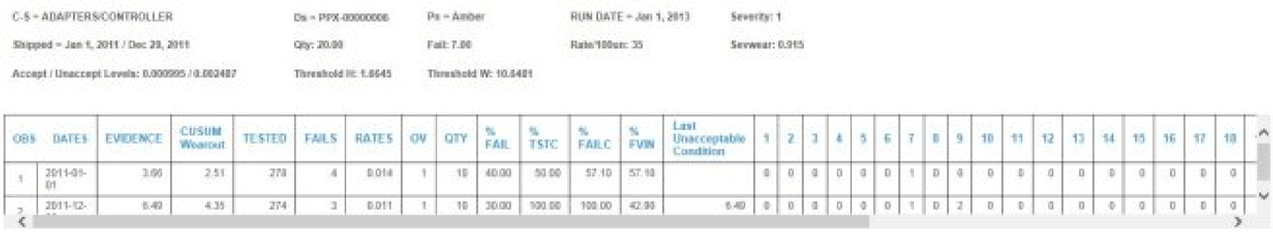


Figure 33. Warranty chart 2

In addition to the above chart the report also shows a summary table.



C-S = ADAPTERS/CONTROLLER Ds = PPX-00000006 Ps = Amber RUN DATE = Jan 1, 2013 Severity: 1

Shipped = Jan 1, 2011 / Dec 28, 2011 Qty: 20.00 Fail: 7.00 Rate/100un: 35 Sevwear: 0.915

Accept / Unaccept Levels: 0.000995 / 0.002487 Threshold H: 1.6645 Threshold W: 10.6481

OBS	DATES	EVIDENCE	CUSUM Wearout	TESTED	FAILS	RATES	OV	QTY	% FAIL	% TSTC	% FAILC	% FVIN	Last Unacceptable Condition	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	2011-01-01	3.66	2.51	278	4	0.014	1	10	40.00	50.00	57.10	57.10		0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
2	2011-12-	6.40	4.35	274	3	0.011	1	10	30.00	100.00	100.00	42.90	6.40	0	0	0	0	0	0	1	0	2	0	0	0	0	0	0	0	0	0

Figure 34. Warranty summary table

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