

IMAC 2014

IBM Predictive Maintenance and Quality (PMQ)

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Agenda

- From Descriptive to Predictive
- PMQ Solution V2
- PMQ Use Cases
- Analytical Decision Management
- Maximo Integration
- Questions



Three types asset analytics answer three types of questions

DESCRIPTIVE highlight status and history:

Which team had the lowest MTTR?

What is our MTBF for our most expensive assets?

Which projects had the most costly over-runs in Q3?

Which inventory parts have not been used in the past two years?

Which location has the highest energy cost per month?

Which location has the highest space utilization?

PRESCRIPTIVE optimize outcomes within constraints:

Which PM schedule will increase technician utilization the most?

For our budget, which warranty program will yield the highest production?

Which re-order points should we change to reduce our excess inventory?

For our construction budget, which plan will yield the highest utilization?

Which energy savings project will yield the highest ROI?

PREDICTIVE present trends and patterns:

Which assets will most likely fail in the next six months?

What type of service request will create the highest cost next year?

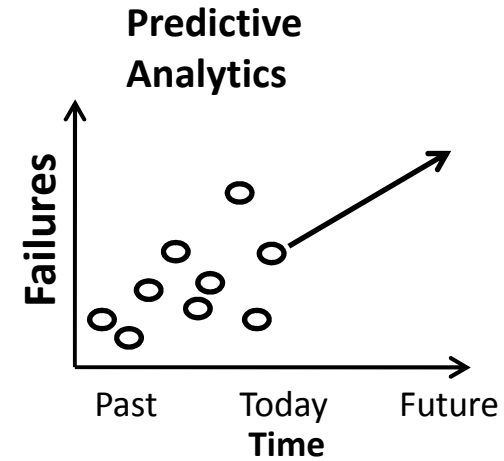
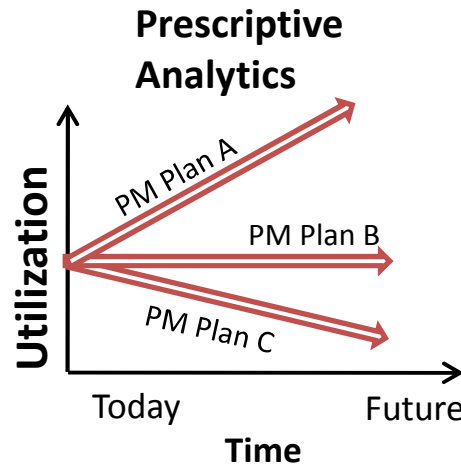
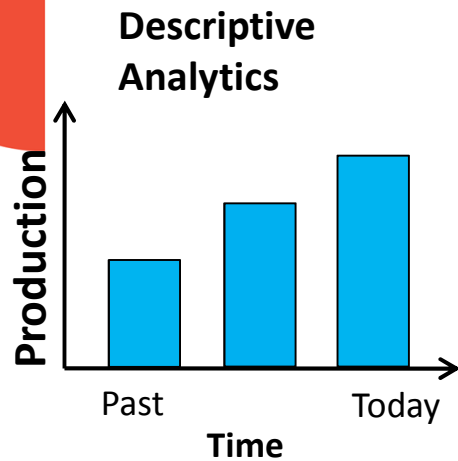
Which parts are most likely to run out of stock?

Which technician skills will we most need next year?

Which technician skills will we most need next year?

Which CAM items in our leases will most likely go unused?

Three most common types of asset analytics



Descriptive	Prescriptive	Predictive
<p><u>Use</u> Prioritize decisions</p>	<p><u>Use</u> Optimize outcomes within constraints</p>	<p><u>Use</u> Anticipate outcomes</p>
<p><u>Process</u> Aggregate applicable values and apply operands to highlight outliers</p>	<p><u>Process</u> Incorporates pre-determined variables, rules and decision criteria</p>	<p><u>Process</u> Prioritizes relevant variables to create trends from historical time-series data</p>
<p><u>Math</u> Standard: addition, subtraction, multiplication, division</p>	<p><u>Math</u> Linear, quadratic and integer programming</p>	<p><u>Math</u> Regression, vector, canonical correlation, multidimensional scaling</p>



Customers validate IBM's analytics strategy



- Sandvik wants a solution that will predict/project failure occurrences for specific asset types.
- Honda and GM want to prevent failures of critical assets in their painting process and predict poor quality electric batteries

Predictive Analytics



- SNCF wants prescriptive maintenance plan scenarios, based on six-month resource availability.
- LIRR wants to create “what-if” scenarios on changes made to their preventive maintenance strategy.

Prescriptive Analytics



- Luminant wants to know what is driving their high maintenance costs and what they can do to address this.
- Duke Energy wants to know how to reduce reserved material inventory due to work order backlog
- Southern Company wants to monitor the number and types of failures occurring to better address and reduce future asset downtime

Descriptive Analytics

Marketplace forces are amplifying day-to-day issues

Lean operations



Complex supply chains



Aging workforce



Customer demands



Raw-material price volatility



Increased Compliance



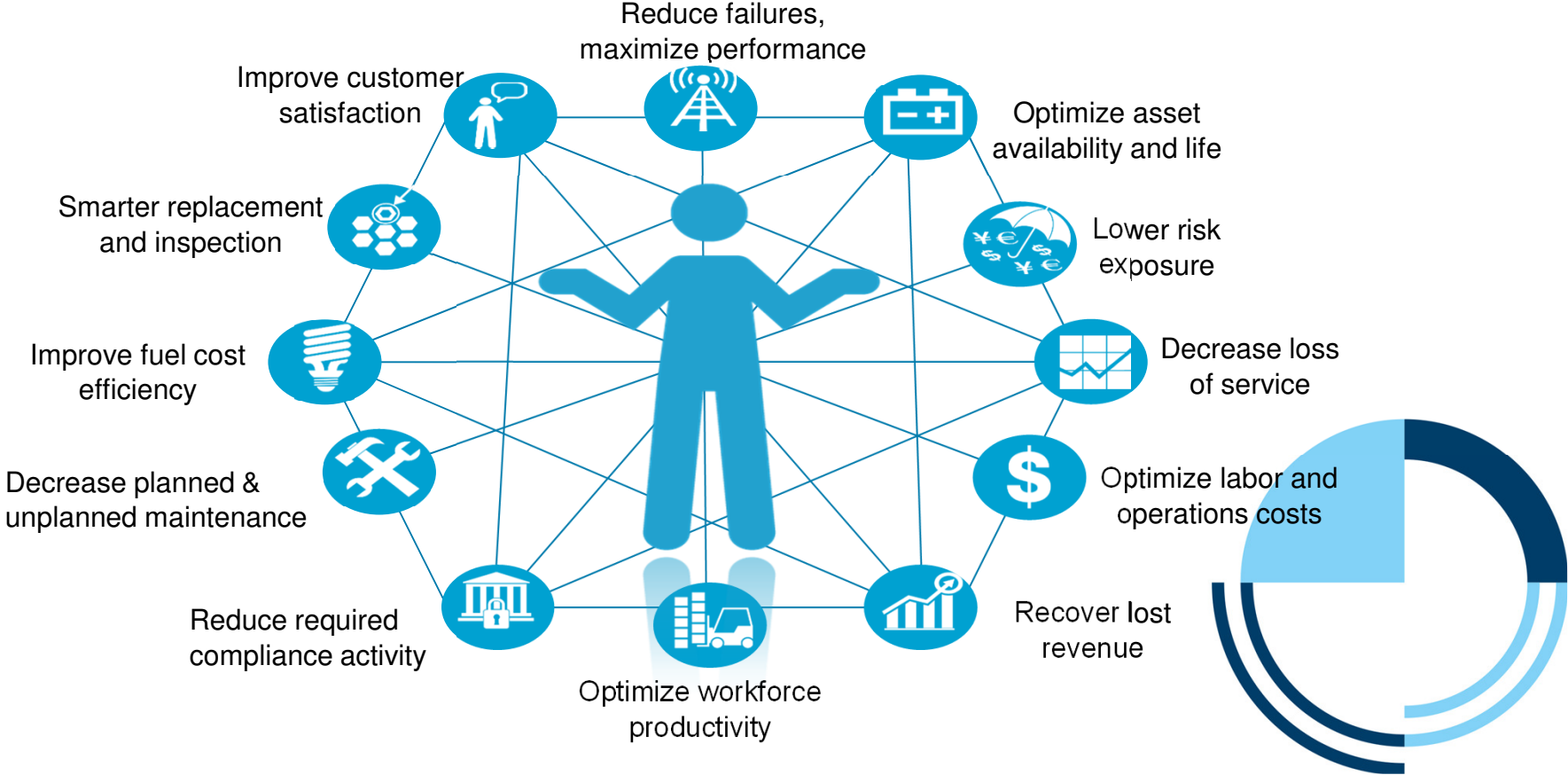
Poor asset performance

- Lack of visibility into asset health
- High costs of unscheduled maintenance
- Inability to accurately forecast asset downtime and costs
- Resultant unnecessary process proliferation
- Aging assets pushed to limits to meet consumer needs

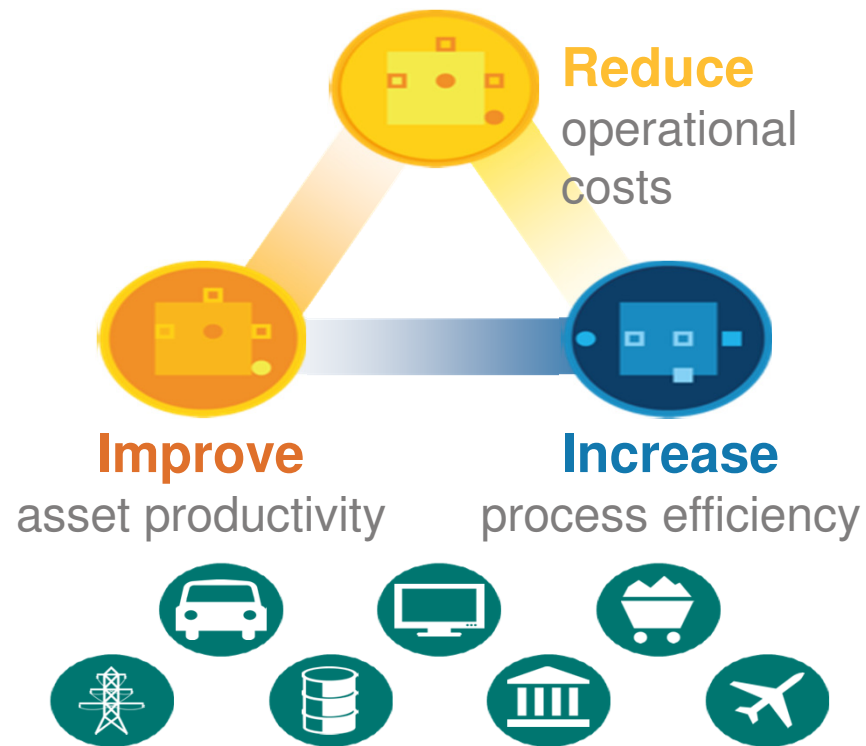
Limited process integration

- Lack of visibility of predictors across organizational silos
- Difficulty synchronizing demand and supply
- Too many manual processes and information sources
- Losses in processes have become normal
- Resource complexity makes it harder to respond to changing needs

And....what if you could?

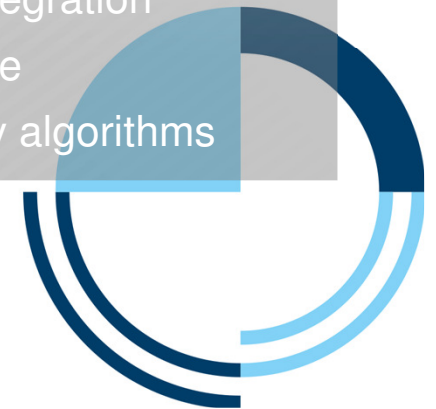


The IBM solution: IBM Predictive Maintenance and Quality



Accelerate time to value

- Real-time capabilities
- Big data, predictive analytics, business intelligence
- Quicker and more-accurate decision making
- IBM Maximo® integration
- Open architecture
- Advanced quality algorithms





IBM Predictive Maintenance and Quality enables better business outcomes

- Monitor, maintain and optimize assets for better availability, utilization and performance
- Predict asset failure and identify poor quality parts earlier to better optimize operations and supply chain processes
- Reduce guesswork and incorporate experiential knowledge during the decision-making process



Includes foundational models, dashboards, reports and source connectors



IBM PMQ V2 is here

What's new?

Enhanced Functionality

New Manufacturing Quality modeling

- Quality Early Warning (QEWS) algorithm
- Inspection Quality during production
- Warranty Analytics, Vintage tracking

Enhanced Maximo Integration

- Failure event capture

Analytic Foundation

- New Java-based APIs for Orchestration, database and data sources

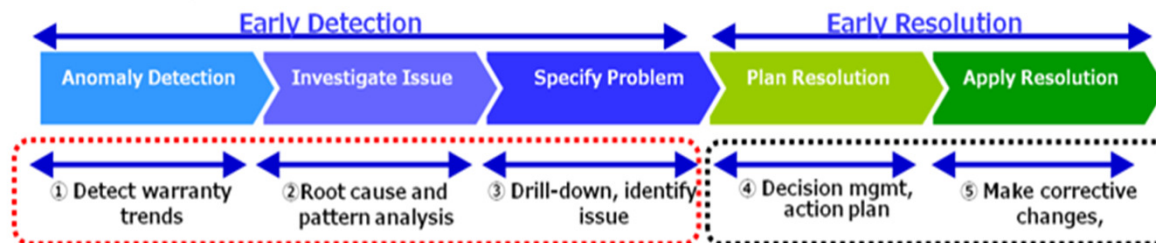
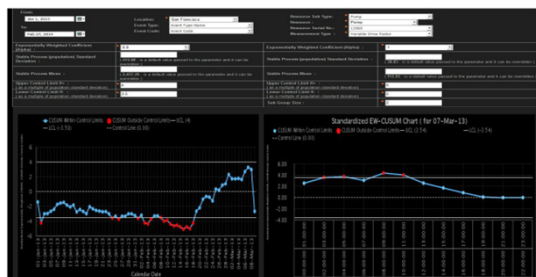
Reporting and Dashboard Enhancement

- Top Failure Causes Report and drill through
- Statistical Process Control Reports
- Equip Health drill down with RAVE


New Maintenance modeling

- New Algorithm (patent pending), combines Text, sensor, maintenance data
- Automatic re-training of models
- New Maintenance Dashboard

New Reports, Dashboards



Case Studies

Smarter and Sustainable Mining 

Australian mining analytics to improve

- Improves** mining equipment availability and uptime
- Increases** revenue and production efficiency
- Reduces** maintenance downtime, parts inventory and costs

THIASS

Smarter Rail 

A rail operator in New Zealand improves performance through predictive

- 2x productivity** among maintenance crews through near-real-time visibility into assets
- Increased safety** and asset uptime with proactive inspection and maintenance practices
- ~83% faster** generation of accurate quarterly compliance reports

Major UK Utility improves asset maintenance & customer satisfaction

- Increases Meter Read by 4x**
Per hour meter reads, increased from once per quarter, providing increased visibility into energy consumption information
- Improved**
Asset maintenance and historical tracking to lower costs through improved preventive maintenance and decision-making



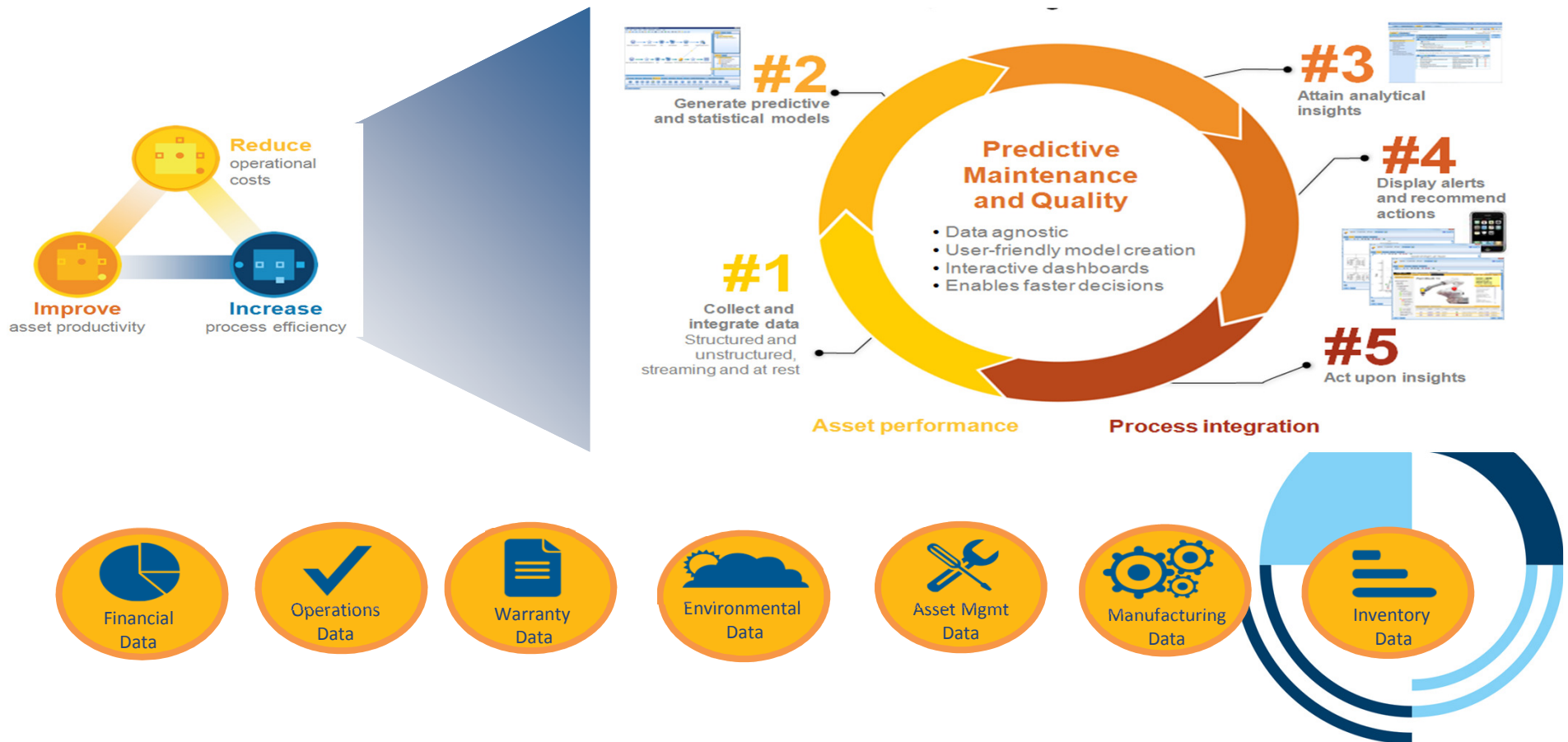
Enables
The company to develop better and more cost effective tariffs, intended to change customer behaviour toward energy consumption

Business Problem: To successfully achieve the requirements of a transformational program, this organisation had to roll out smart meters, reduce costs & improve efficiencies and customer satisfaction

Solution: Advanced analytics solutions give near real-time visibility into energy consumption across the grid via smart meters, enabling it to manage electricity flow more precisely. Combined analysis of consumption data with customer information enables call center agents to offer the most appropriate electricity or gas rate plan to meet a customer's needs. An advanced asset management solution that performs both preventive and reactive maintenance, provides critical information to enable this utility to drive down asset costs and improve performance.

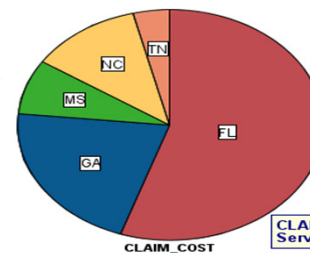
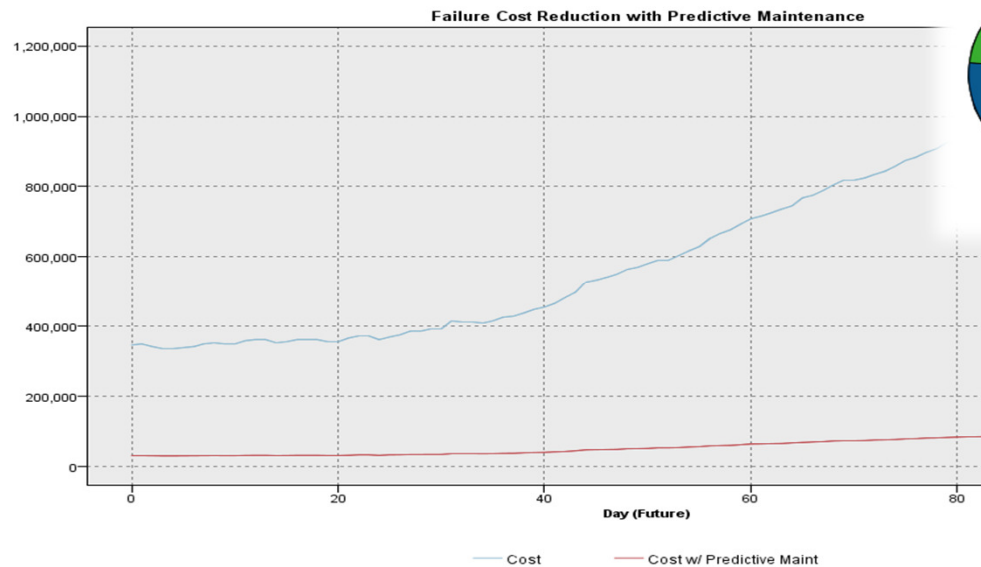


PMQ analyzes data from multiple sources and provides recommended actions, enabling informed decisions

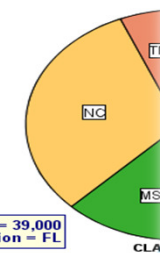


What is the cost of maintenance & failures?

- How do costs vary by region? Why do they vary?
- What is the total cost of ownership of each piece of equipment?
- What will repairs cost me next year?



CLAIM_COST = 39,000
Service.Location = FL



Schedule costs are greatly reduced, less service interruption and increased customer satisfaction



Anomaly Detection – how is it done?

grantfraudN.db

Anomaly

Anomaly

Field Reorder

Select

Table

customersalesvolume ...

Table (19 fields, 10 records)

	id	\$O-Anomaly	\$O-AnomalyIndex	\$O-PeerGroup	\$O-Field-1	\$O-FieldImpact-1	\$O-Field-2	\$O-FieldImpact
1	id633	T	1.600	2	claimvalue	0.358	annualincome	0.275
2	id647	T	1.403	2	annualincome	0.334	claimvalue	0.161
3	id654	T	1.495	2	annualfailurestodate	0.322	enginetype	0.181
4	id703	T	1.358	1	annualfailurestodate	0.230	region	0.219
5	id704	T	1.427	2	annualincome	0.267	enginetype	0.190
6	id739	T	1.684	2	claimvalue	0.404	annualincome	0.233
7	id752	T	1.770	2	claimvalue	0.391	annualincome	0.155
8	id791	T	1.386	1	enginetype	0.236	annualfailurestodate	0.163
9	id813	T	1.641	1	region	0.181	qualitygroup	0.160
10	id883	T	1.350	2	region	0.187	enginetype	0.169

Plot of customersalesvolume v. claimvalue #1

claimvalue

customersalesvolume

\$O-Anomaly

Peer group-1: 202 records

Anomalies: found 3 records from an estimated total of 202 records

Peer group profile

- annualfailurestodate (56.594)
- annualincome (291679.895)
- claimvalue (86185.011)
- customersalesvolume (1087.624)
- qualitygroup (5.634)
- claimtype (decommission_land -> 56.93%)
- enginetype (wheat -> 43.56%)
- region (southeast -> 38.12%)

Identify anomalous production data and show the specific data that is out of tolerance

Peer group profile compared to anomalous runs

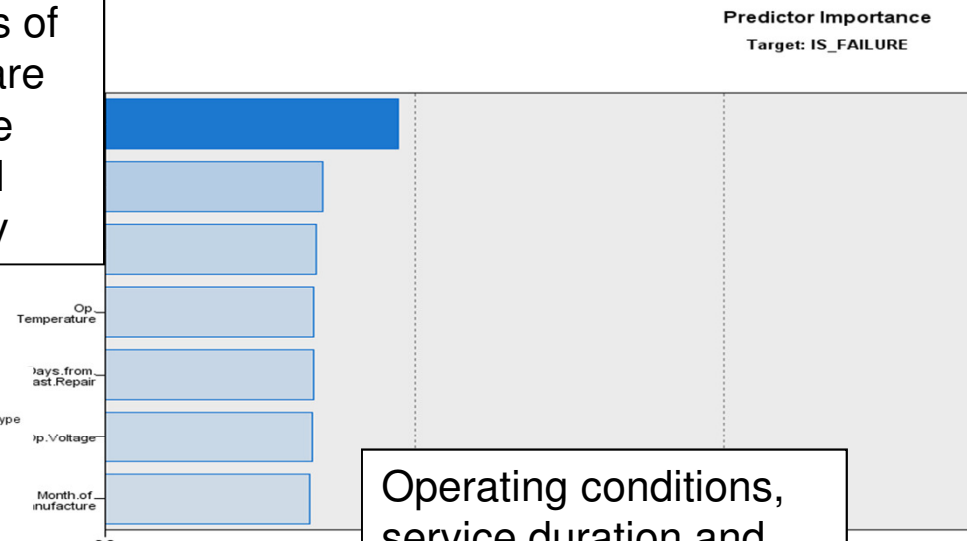
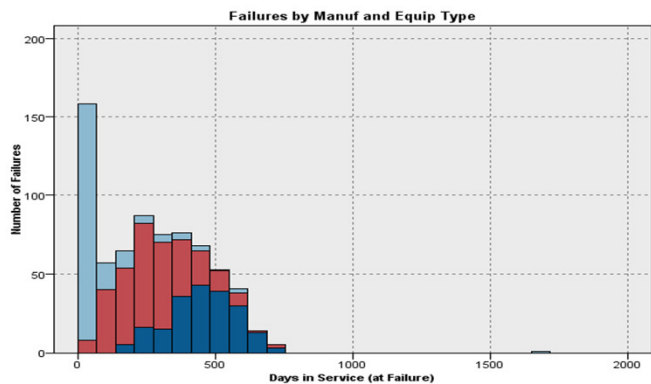
Root Cause Analysis of Failures

What is parts are failing? What is driving the failure?

```

Rules for 1 - contains 4 rule(s)
  Rule 1 for 1
  if Days.in.Service > 364.780
  then 1
  Rule 2 for 1
  if Days.in.Service <= 35.329
  and Op.Voltage <= 225.409
  and Op.Amperage > 21.661
  and Days.from.Last.Service <= 20.662
  then 1
  Rule 3 for 1
  if Days.in.Service > 5.847
  and Days.in.Service <= 21.354
  and Op.Amperage > 21.661
  and Op.Amperage <= 23.794
  then 1
  Rule 4 for 1
  if Op.Temperature > 72.303
  then 1
Rules for 0 - contains 41 rule(s)
Default: 1
    
```

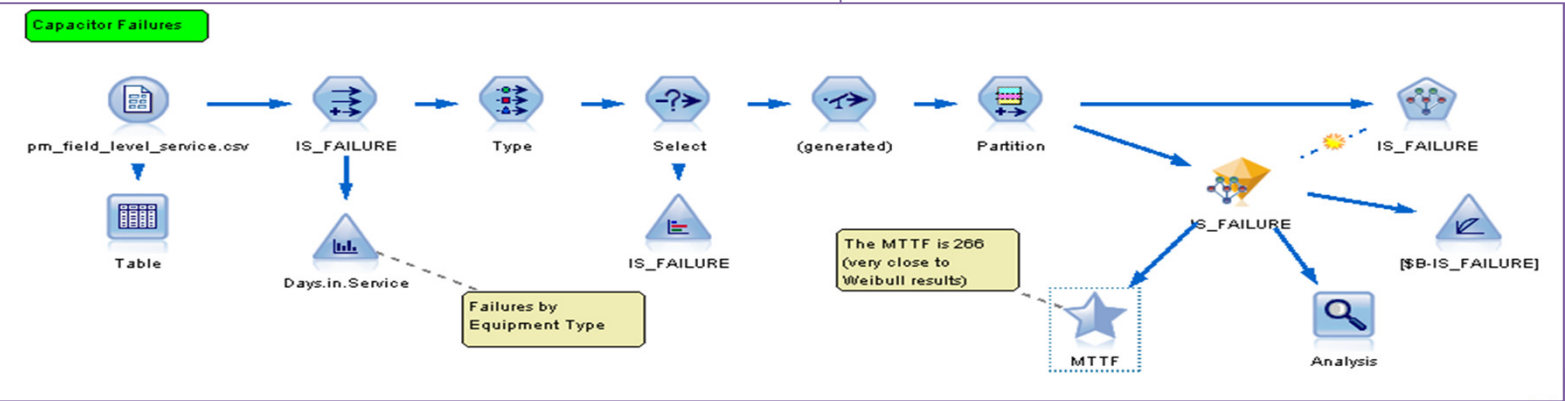
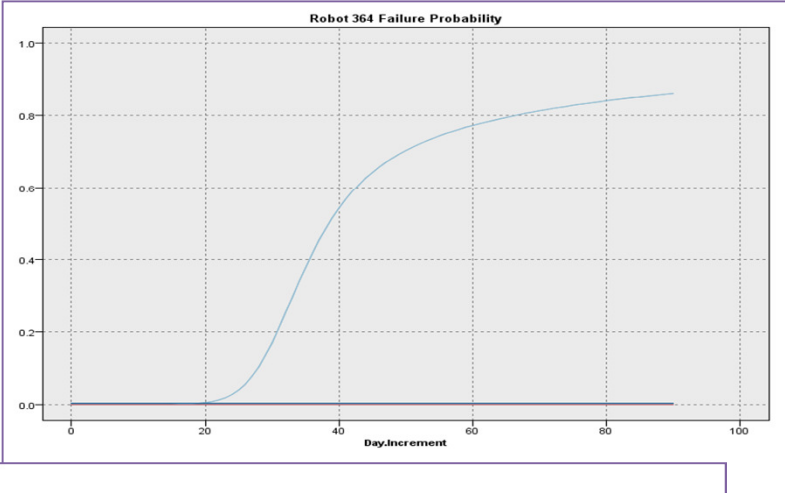
4 specific combinations of factors that are driving failure are identified automatically



Operating conditions, service duration and manufacturing quality all play a role in the failure likelihood

How Likely Is a Failure at Time X?

- **Leverage all available data**
 - Sensor logs, maintenance logs, condition monitoring data, etc.
- **Build predictive models**
 - Estimate the failure likelihood at any point in the future for every piece of equipment
 - Neural Nets, Logistic Regression, Decision Trees, SVM, SLRM, etc.
- **Apply models to new data**
 - Generate updated failure likelihood values

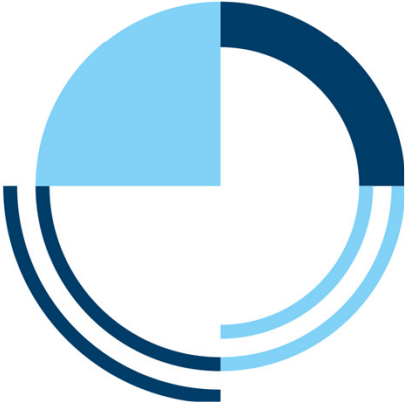


Decision Management

Define tab lists possible failures along with preventive actions

The screenshot shows the IBM Analytical Decision Management for Predictive Maintenance interface. The 'Define' tab is active, showing a table of rules for the 'Robotic Arm Malfunction' use case. The table lists rule names, their conditions, and the actions they trigger. The 'Allocate to' dropdown is set to 'All Match Rules'.

Rule name	Allocation	Insert rule	Remove
1 Fractured parts or parts predicted to fail Actual.Failure.Equipment.Type = STRESS FRACTURE OR \$XS-Failure.Equipment.Type ONE OF (STRESS FRA	Replace Fractured Part; Perform Maintainer	Insert rule	Remove
2 Low rotor speed	Tighten Lead Screw; Check Stepping Mo	Insert rule	Remove
3 High voltage	Replace Fractured Part; Perform Maintainer	Insert rule	Remove
4 Predicted driver failure	Check Drivers	Insert rule	Remove
5 Time since last service above threshold	Check Drivers; Perform Maintenance	Insert rule	Remove
6 Remainder	Perform Maintenance	Insert rule	Remove



Predictive maintenance application

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*A second allocation determines **who** can take action based on skill set, cost, and availability*

The screenshot displays the IBM Analytical Decision Management (ADM) interface for Predictive Maintenance. The main window is titled "predictive_maintenance" and includes a navigation bar with tabs for "Data", "Global Selections", "Define", "Optimize", and "Deploy". The "Define" tab is active, showing a "Service Group" configuration page. On the left, a "Search Dimensions" panel lists three levels: "Level 1 - Technician", "Level 2 - Engineers", and "Level 3 - Expert Engineers", with "Level 3 - Expert Engineers" selected. The main area is titled "Choose Who This Service Group Applies to" and contains a table of rules. The table has two columns: "Rule name" and "Include/Exclude". A single rule is listed with the name "All Issues Excluding Regular Maintenance" and an "Include" status. The rule details show a condition: "Use Case = Robotic Arm Malfunction" OR "Use Case = Drill Bit Issue", leading to the action "Action != Perform Maintenance".

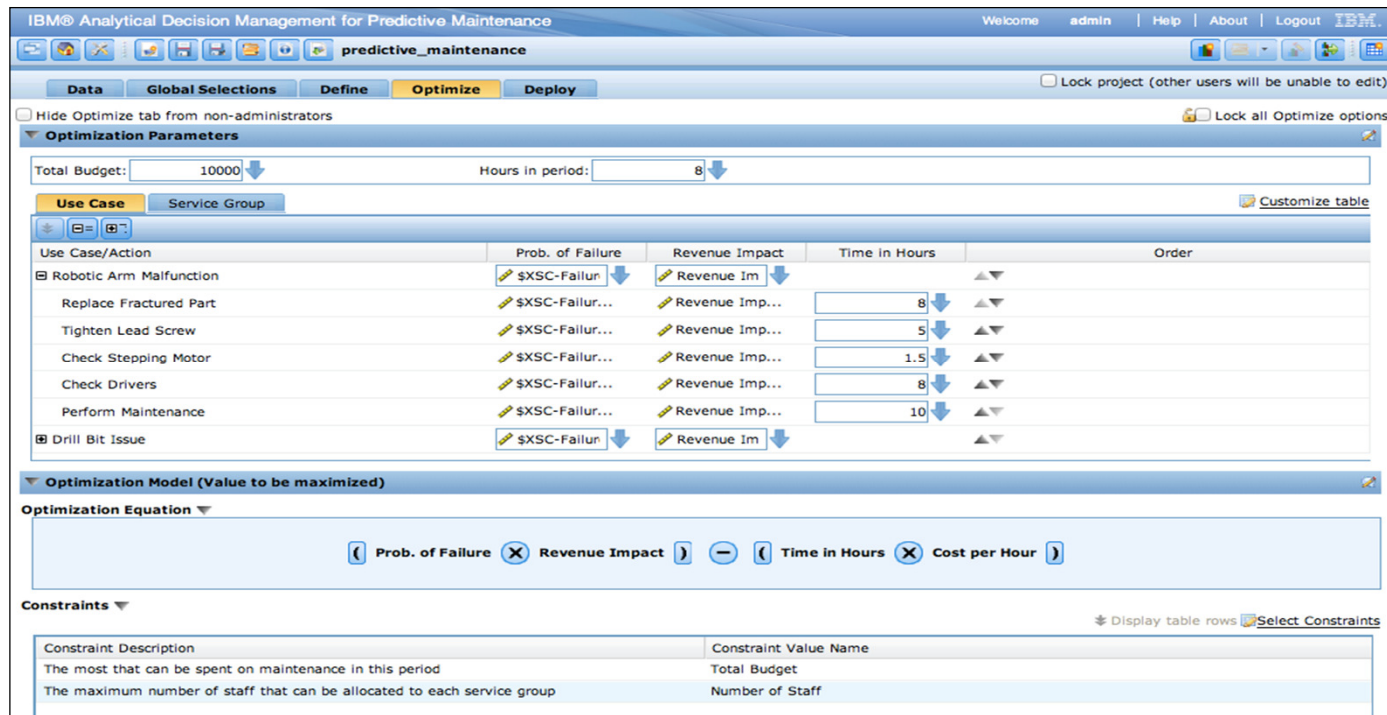
Rule name	Include/Exclude
1 All Issues Excluding Regular Maintenance Use Case = Robotic Arm Malfunction OR Use Case = Drill Bit Issue Action != Perform Maintenance	Include



Predictive maintenance application

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Optimization identifies the combination of actions that yields the highest cost savings



The screenshot shows the 'Optimize' tab of the IBM Analytical Decision Management for Predictive Maintenance application. The interface includes a navigation bar with 'Data', 'Global Selections', 'Define', 'Optimize', and 'Deploy' tabs. The 'Optimize' tab is active, showing 'Optimization Parameters' with a 'Total Budget' of 10000 and 'Hours in period' of 8. Below this is a table of use cases and actions, and an 'Optimization Model' section with an equation and constraints.

Use Case/Action	Prob. of Failure	Revenue Impact	Time in Hours	Order
Robotic Arm Malfunction	\$XSC-Fallur	Revenue Im		
Replace Fractured Part	\$XSC-Fallur...	Revenue Imp...	8	
Tighten Lead Screw	\$XSC-Fallur...	Revenue Imp...	5	
Check Stepping Motor	\$XSC-Fallur...	Revenue Imp...	1.5	
Check Drivers	\$XSC-Fallur...	Revenue Imp...	8	
Perform Maintenance	\$XSC-Fallur...	Revenue Imp...	10	
Drill Bit Issue	\$XSC-Fallur	Revenue Im		

Optimization Model (Value to be maximized)

Optimization Equation: $(\text{Prob. of Failure} \times \text{Revenue Impact}) - (\text{Time in Hours} \times \text{Cost per Hour})$

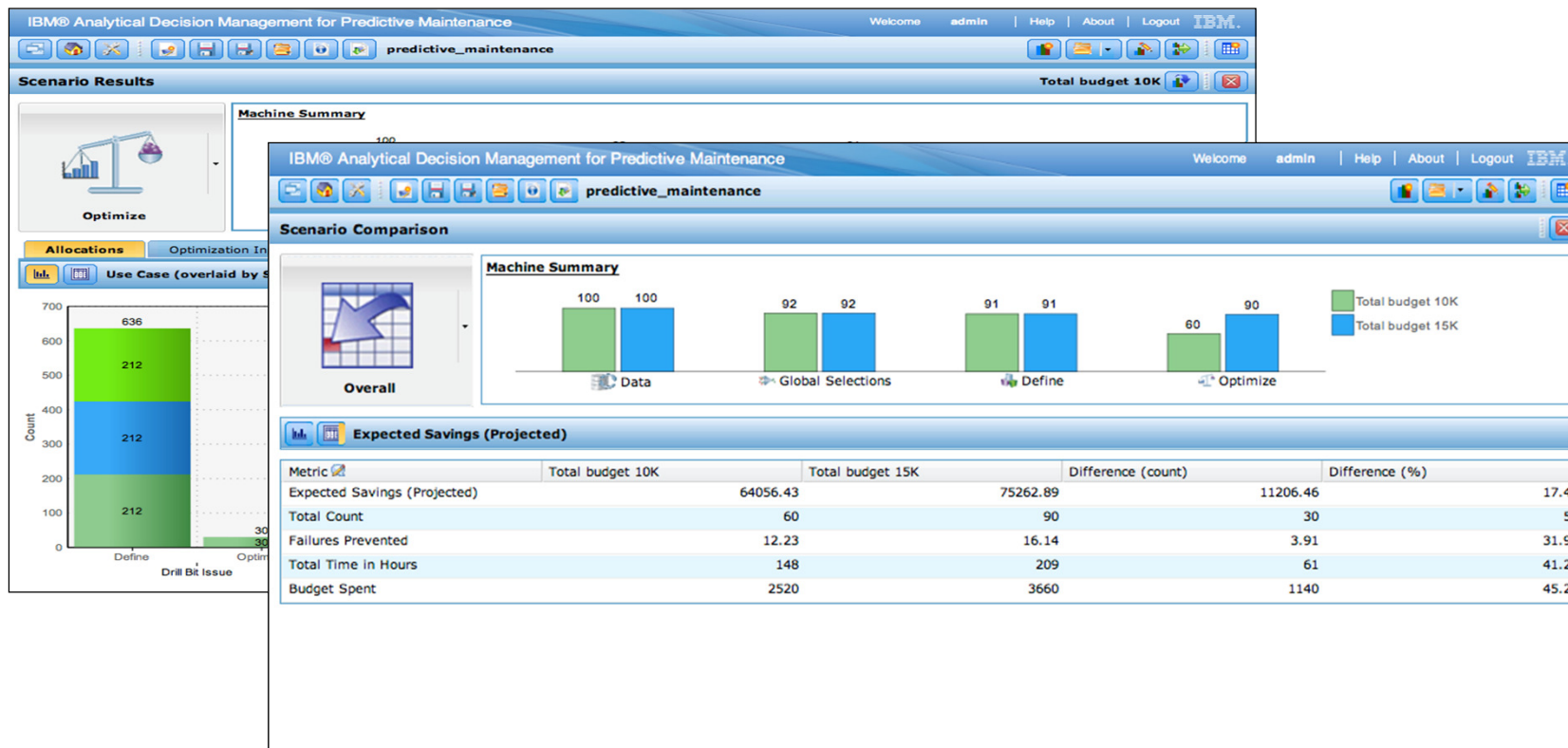
Constraints

Constraint Description	Constraint Value Name
The most that can be spent on maintenance in this period	Total Budget
The maximum number of staff that can be allocated to each service group	Number of Staff



Predictive maintenance application

Scenario results show impact on the bottom line & comparisons of changes made



The screenshot displays the IBM Analytical Decision Management for Predictive Maintenance interface. It features several key components:

- Scenario Results:** Shows a 'Machine Summary' for a 'Total budget 10K' scenario.
- Scenario Comparison:** Compares 'Total budget 10K' (green bars) and 'Total budget 15K' (blue bars) across four stages: Data, Global Selections, Define, and Optimize. The counts are: Data (100 vs 100), Global Selections (92 vs 92), Define (91 vs 91), and Optimize (60 vs 90).
- Expected Savings (Projected):** A table comparing metrics for the two budget scenarios.
- Allocations:** A bar chart showing 'Use Case (overlaid by S)' with categories 'Define' and 'Optimize'.

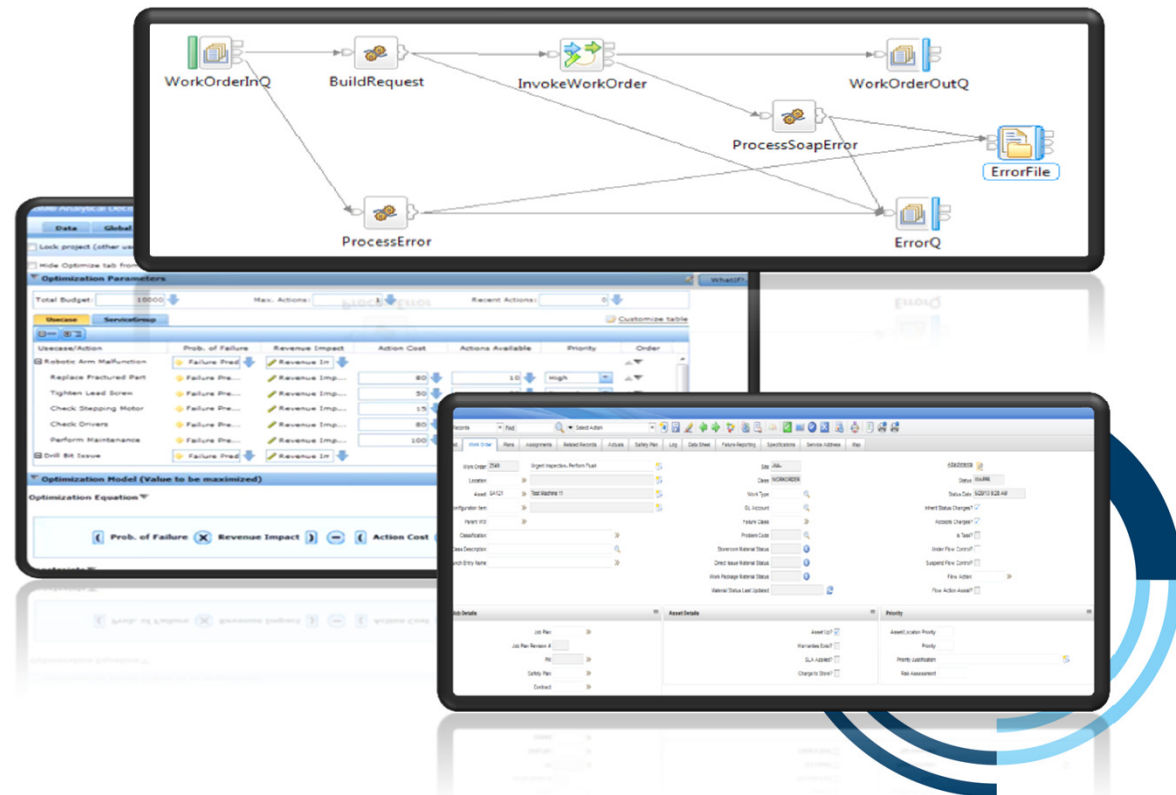
Metric	Total budget 10K	Total budget 15K	Difference (count)	Difference (%)
Expected Savings (Projected)	64056.43	75262.89	11206.46	17.49
Total Count	60	90	30	50.00
Failures Prevented	12.23	16.14	3.91	31.97
Total Time In Hours	148	209	61	41.22
Budget Spent	2520	3660	1140	45.24

Maximo Integration



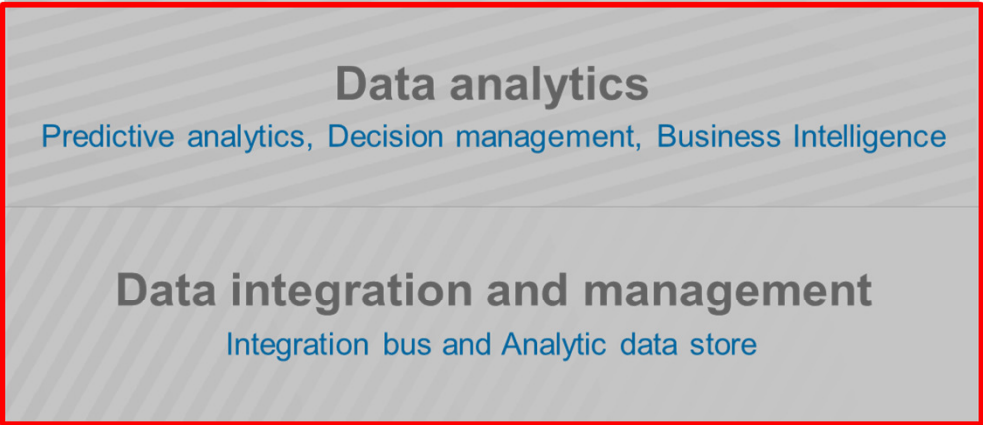
Features

- Integrate directly with Enterprise Asset Management systems, such as IBM Maximo
- PMQ leverages asset master and fault data from Maximo
- Master data is synchronized between Maximo and PMQ
- PMQ generates work orders based on analytic insight and business rules
- Directly act upon predictive insights with system of engagement



PMQ Architecture

End user reports, dashboards, drill downs



Consume insight anywhere eg. mobile

Predictive analytics, decision management & reporting combined

Industry specific blueprint for data layer

Bi-directional flow with Maximo

▲

Telematics, manufacturing execution systems, existing databases, distributed control systems

▲

High-volume streaming data (Streams), IoT, MQTT (MessageSight)

◆

Enterprise asset management systems (Maximo)



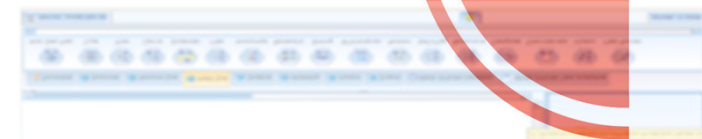
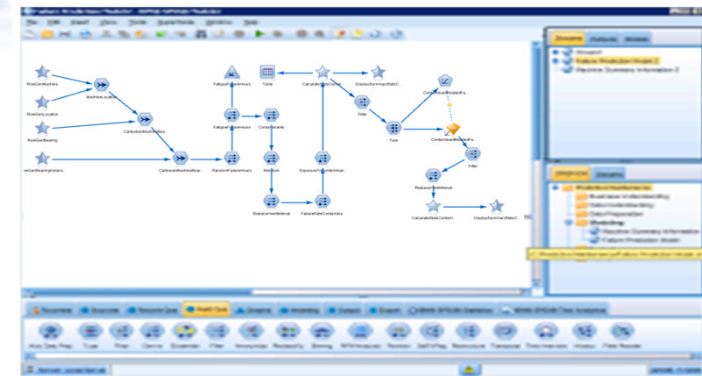
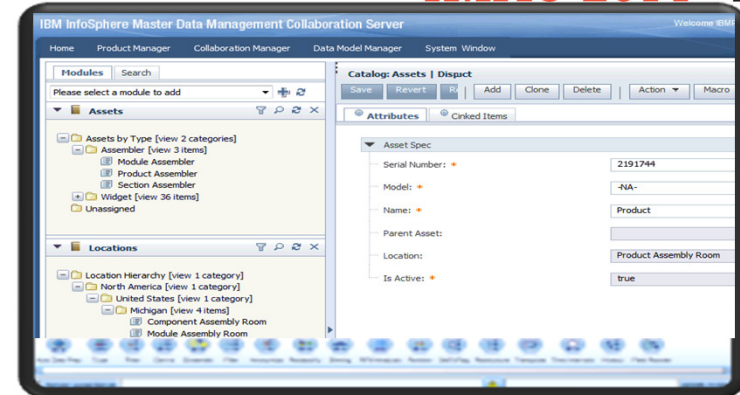
Accelerated Time to Value



Features

- Leverage easy-to-install, preconfigured software and content stack
- Utilize out-of-the-box data source connectors and models, dashboards and reports to reduce the need for additional services
- Quickly expand or modify included models for specific industry and business applications
- Easily access business user interface for master data entry and modification
- Seamlessly integrate partner provided content

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Ultimately affecting the bottom line

Predictive Maintenance

- ✓ Averting unplanned downtime
- ✓ Scheduled/planned, predictive
- ✓ Addressing asset utilization
- ✓ Warranty capabilities

Quality – Lean Sigma

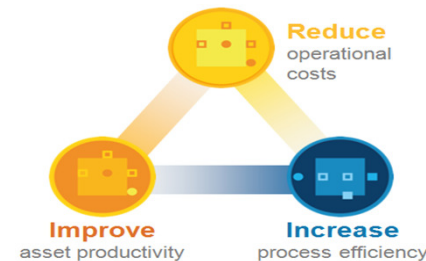
- ✓ Extend process improvement
- ✓ Root cause analysis & SPC
- ✓ Supply chain

Field Asset Monitoring

- ✓ Equipment monitoring for production
- ✓ Asset monitoring for new service(s)
- ✓ Field asset optimization
- ✓ Inventory management
- ✓ Fleet and facilities management

The Value of PMQ

1. Lowering Unit/Item Cost (Improving profit/margin)
2. Increasing Production “Yield”(Productivity)
3. Superior ROA and “Asset Optimization”
4. Higher Revenue due to Quality Improvement
5. Increased Competitiveness due to higher Quality
6. New Services for Health Monitoring of Assets
7. Lower Risks due to fewer or elimination of Asset Failures



Thank you.

