From Concept To Manufacturing

Graham Bleakley Ph.D
Rhapsody Offering Manager
Outline

• Industry 4.0 vision
• Product Engineering, PLM and Digital Twins
• Manufacturing Analytics
  • PM, PPA, PQ, PW
• Traceability Threads
• Adding cognitive
Capabilities required to enable the 4th Industrial Revolution

- Ability to connect and manage devices
- Near real-time data collection
- Insights of what is happening
- New business models

- Flexible machines
- 3D printing
- Machine to machine
- New standards and protocols

- Smart and networked products
- Ability to communicate thru the Internet
- Self diagnose / self awareness

- The API economy
- Vertical / horizontal integration across value chains
- New delivery channels and business models

- Embedded in equipment, products and services
- Predict what may happen
- Prescribe actions for best outcomes
- Self learning
- Communicate in natural language

Sources: Acatech: Recommendations for implementing the strategic initiative Industrie 4.0, April 2013; Gartner: Industrie 4.0- The Ten Things the CIO Needs to Know; Deutsche Bank Research: "Upgrading of Germany’s industrial capabilities on the horizon", April 2014
Our Vision: Transforming Product Innovation
From Engineering to Manufacturing

- Realize industry 4.0 vision
- Understand and leverage all your data
- Enable Autonomicity
- Assistance and decision making
- Vertical and Horizontal integration
- Results in
  - Improved efficiency and productivity
  - Improved working environment
  - Accelerated innovation

**Advanced Analytics**
- Predictive Analytics
- Real-time Analytics
- Data Mining
- Optimization

**Cognitive Technology**
- Natural Language Processing
- Machine Learning
- Textual Analytics
- Video/Image Analytics
- Augmented reality

**Data & Big Data Integration**
- Weather data
- Social data
- Application data
- Platform of platforms

**Partnered Innovation**
- Open ecosystem
- Device partnerships
- Embedded security
- Edge Analytics

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Continuous Engineering: transforming systems engineering to a complete digital process

- Requirements management
- MBSE - Model Based System Engineering
- MDD – Model Driven Software Development
- Quality management
- Automated testing
- End to End Traceability
- Change management
- Version and configuration management
- Planning and tracking
- Process enactment
- Cross lifecycle Analytics & Reporting
- Automated document generation
Flywheel™ by Persistent Systems

- Service offering to develop IoT Solutions
- MBSE used to describe the four IIRA viewpoints
- Auto. deploy and config. of cloud services and applications

Connect

 IoT Rhythm

Data Integration

API Ecosystem

Multi-modal Apps

Analytics/Cognitive

Continuous Engineering

Learn

Abstract

Visualize

Improve
Flywheel Continuous Engineering in a Nutshell

Engineering

“Flywheel Modeler”

[RDM] DNG

CE

RQM

RTC

Flywheel Engine

CLM: Collaborative Lifecycle Management
DNG: DOORS Next Generation
RDM: Rhapsody Design Manager
RQM: Rational Quality Management
RTC: Rational Team Center

Tools are configured/customized

Runtime platform

Deploy/Config.

Config. & Runtime data

Watson IoT Platform
Device Simulator
API Connect
Bluevega
GIT

Share Insights
MAXIMO
PMQ
DB
ML
...

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ARAS PLM

• A PLM tool like Aras Innovator is a key enabler to complete the representation of the digital twin with references of **physical** domains like mechanical and electrical. Aras also maintains references to the RFL objects so a mapping can be defined from the logical to the physical and impact and change propagations are controlled and managed.
Digital Twins are virtual representations for a purpose, like planning, analysis, simulation or operational performance.
Product Perspective: Vertical Integration from Concept to Manufacturing

- Requirements
  - Logical Design
    - Functional Design
      - Physical Design – PLM E-BOM
      - Manufacturing – PLM M-BOM
    - Operation – As maintained BOM

- The Thread

- IBM Maximo
- IoT Platform
Tracing Engineering BOMs and Manufacturing BOMs with Aras Innovator

- Version controlled MBOM derived from EBOM using
  - Drag and drop editing
  - Concurrent process plan and MBOM creation
- Automatic EBOM/MBOM reconciliation
- Plant-specific MBOMs and process plans
- Version controlled process plans detailing operations, steps, parts consumed, resources utilized, skills, documents referenced etc
- Concurrent authoring of visually rich electronic work instructions
Analytics capability is enabling the new insights over Digital Twin content and condition.
Digital Twins & Threads

Augmentation by analytics
New perspectives & insights
Design in context for IoT Systems
System test meets requirements
Aggregated control of configured items & changes
New manufacturing insights
Traceability queries in context
Predictive in-service analytics
Cognitive insights
3 Tier Manufacturing Architecture (IIC Terminology)

Enterprise Tier
- Web Services, Files
- B2BML/OPC UA, Proprietary XML
- SOAP, XML
- JMS
- Web Services
- IDOC/BAPI, SQL
- Web Services
- IDOC, BAPI SQL
- Web Services
- Proprietary interfaces

Platform Tier
- Analytics
- Workflow
- Msg/Event Mediation/Handling
- OPC UA
- Web Socket TCP
- MQTT
- HTTPS

Edge Tier
- Streaming Analytics (Quarks)
- OPC DA
- OPC HDA
- OPC AE
- OPC Classic Server (including Historian)
- OPC UA Server (including Historian)
- Fieldbus
- PLC
- Proprietary (e.g. Profibus)

UI/Mobile
- Remote Telemetry Unit or Embedded Sensor
- MQTT (to any level)

Corporate Applications
- ERP, Production Scheduling
- Dynamics
- Oracle
- SAP
- SOAP, XML
- JMS

Supply Chain Management
- OAGIS, EDI etc

Asset Management
- Engineering/PLM
- Web Services
- Mimosa
- Web Services
- PLCS, SPEC 2000

Engineering/PLM
- Supply Chain Management
- Mfg. Plant/Shop Floor
WIoT connected manufacturing functional stack

**Gateway/Edge**
- IBM Edge Analytics, via Partners (CISCO, Intel, etc)
- (Router, Broker, Streaming, Connection SDK)

**Bluemix IaaS/PaaS**

**Analytics Engines**
- IBM IIB/Mfg Pack (satellite link)
- Remote Site
- Plant Staff
- Mobile Applications
- Manufacturing Execution Systems
- OPC Classic Server
- OPC UA Server

**IoT Platform**
- WEX Watson Cog Services
- OSISoft PI Server

**Accelerators/Offerings**
- Equipment Advisor, Connected Workstation, Cognitive Workplace

**Cognitive Analytics**
- Predictive Analytics
  - Prescriptive Maintenance
  - Prescriptive Quality
  - Plant Performance Analytics
  - Prescriptive Warranty

**Reports**

**OEM Apps**

**Continuous Engineering**

**PDM**

**EAM – Maximo**

**ERP**
Cognitive Analytics For Manufacturing

- Asset Analytics
- Cognitive Process and Operations
- Cognitive worker assistance
Intelligent assets and equipment utilizes IoT and cognitive capabilities to sense, communicate and self-diagnose issues so they can optimize their performance and reduce unnecessary downtime.

- Prevent production delays and improve line performance with better asset visibility
- Reduce equipment downtime and increase process efficiency with industry models
- Expedite equipment repairs through predictive and cognitive analytics

Decrease in equipment downtime at major global auto manufacturer: 34%
Maximo, and the Watson IoT Platform delivering value together

1. Real Time data from low cost add-on sensors

2. Real time filtered data from automation systems

3. Historical sensor data

4. Historical Weather data

Asset Scoring

This asset’s health is 81.
This was derived from the following 6 driver values:

- 1. Fan: 95% Remaining Useful Life
- 2. Motor: 30% Remaining Useful Life
- 3. Exhaust system: 95% Remaining Useful Life
- 4. Battery: 30% Remaining Useful Life
- 5. XX of Y driver value: 18 yrs out of 20
- 6. XX of Y driver value: 18 yrs out of 20

IBM Watson IoT Platform
Easily and quickly obtain insight with WIoT predictive maintenance

- Pre-configured solution – does not require data science experts
- Integrate, ingest, and analyze operational data – structured and unstructured – sensors, SCADA, IoT devices, environmental, work order history
- Predictive models determine likelihood of asset failure and time to failure
- Identify top failure modes
- Asset health scores evaluate operational data in real-time
- Determine optimum response to alerts based upon asset health
- Recommend optimal maintenance schedule and maintenance procedures
- Integrate with EAM systems such as IBM Maximo and SAP PM
Predict asset performance
Plant Performance Analytics: Overall Equipment Effectiveness (OEE)

Predicts Potential OEE Losses, Prescribes Remedies, and Maximizes OEE

bottleneck – machine #1 is delaying production

Target Product Count

Downtime loss

Quality loss

Performance loss

Net loss of Operational Effectiveness

Actual Product Count
IBM Plant Performance Analytics

ISA 95 Info Model

Transactions
EAM
CMM
Production Plan

Positional
Parametric
Events

Cycle time

Industry Analytical Models

IBM Analytics Platform

Predictions
- Issue prediction
- Probability of occurrence
- Time to occurrence
- Root cause
- Probable time to recover

Prescriptions
- Recommended repair plan
- Recommended action

Plant OEE

Overtime

Maintenance

Materials
Quickly assess equipment availability

Assess availability overall and by shift

Obtain metrics regarding equipment status, alerts and maintenance activities

Navigate hierarchy to visualize asset health and identify assets with critical alerts (predictions)

Determine status of area, line, station and individual equipment
Optimize Process and Operations

Cognitive operations and processes bring more certainty to business by analyzing a variety of information from workflows, context and environment to drive quality, enhance operations and decision-making.

- Increase yield of your manufacturing operations and processes
- Improve productivity of your manufacturing line with early quality detection
- Expedite service calls and repairs and reduce warranty costs

Increase in overall productivity at major European automaker 25%
IBM Prescriptive Quality

Earlier, more definitive quality problem detection
Prevent subtle problems from going undetected
Ignores statistical anomalies
Low false alarm rate
Designed for line of business
SaaS implementation

Capture data when a test is performed, an inspection is done, a measurement is made.

Objective: early insight reduces cost

POS
Quality
Maintenance

aggregate
analyze, report & alert
act

materials & components  processes  products
IBM Quality Early Warning System

Unique IBM technology to detect and prioritize quality problems and parametric shifts earlier and more definitively than traditional SPC methods

**IBM QEWS**

- Timely detection of unacceptable process behavior while maintaining low false alarm rate
- Typically requires fewer data points than SPC for given level of statistical confidence
- Ignores statistical anomalies – only alerts on real changes
- More definitive alerts - hours, days, weeks, months earlier
- Visible trends - even before traditional control limits have been crossed

**Statistical Process Control**

- Traditional tool to identify process quality problems
- Small sample sizes can contribute to false positives
- Alerts on abnormal patterns which may have no practical significance
- Slow detection of small and moderate changes
- Trends not readily visible

- Used throughout IBM’s integrated supply chain and by hundreds of IBM engineers
- Saves IBM over $10M annually by earlier problem detection and cost avoidance
Example: Quality Analytics Line Operator Personal Dashboard

Issues detected in key parameters. Pull the board from the line and set aside for the Engineering Team to review.
Manufacturing Process Engineer collaborates with the Design Engineer through Predictive Quality (PQ) + Continuous Engineering (CE)

A Process Engineer can use PQ to explore past and present predictions to assess the relationship between early warnings and actual alerts, and collaborate with the Design Engineer to determine:

1) if the process parameters are complete and are stringent enough to ensure the required yield and scrap rates required by the product, and

2) what aspects of the design are most sensitive to process variations.

How the solution will work
- CE: Identify requirements/constraints for the manufacturing process (e.g. final/intermediate yields, scrap rates, and throughput) that are required to produce successful product
- CE: Identify the key manufacturing variables to monitor and pass to Predictive Quality models
- PQ: provide production alerts using initial information prepopulated from CE
- CE/PQ: provide traceability from design elements in CE to model parameters in PQ
- CE/PQ: perform what-if analyses on proposed Engineering Change Requests in product or process

Benefits:

- Cognitive insights to increase yield, reduce scrap
- Continuous improvement of process and product quality
- In-context collaboration between different players
- Real-time governance
Reliability Engineer collaborates with the Process Engineer and Design Engineer (PW +PQ + CE)

• A Reliability Engineer in the field can explore past and present performance issues to assess the relationship between early warnings and actual failures, and collaborate with the Design Engineer to do root cause analysis and trade-off analysis to determine the optimal fix to the problem.

How the solution will work
- CE: Identify requirements/constraints for manufacturing process (e.g. final/intermediate yields, scrap rates, and throughput) and field performance (e.g. MTBF, acceptable replacements rates) needed to have a successful product
- CE: Identify key manufacturing and in-market variables to monitor to ensure conforming product
- PW: Based on aftermarket and service data, PW provides alerts when early product wear-out occurs or replacement rates are unacceptable
- CE/PQ: provides traceability from design elements in CE to model parameters in PQ and product
- CE/PQ: perform what-if analyses on proposed Engineering Change Requests in product or process

Benefits:
• Cognitive insights to increase product reliability, reduce recall
• In-context collaboration between different players
• Real-time governance
• Lifecycle traceability
• Reduced warranty costs
Cognitive worker assistance

Utilize IoT and cognitive insight to optimize the resources engaged around production, whether that’s keeping production line workers safe, improving the expertise of the entire workforce.

- Increase worker productivity and expertise
- Improve worker safety and gain better workforce management
Watson IoT Equipment Advisor

Connect, Predict, Repair and Optimize your equipment with IoT and the power of Watson

1. Sensors provide information about the device
   - Robots
   - Medical devices
   - Transformers
   - Turbines
   - Engines

2. Data comes in through Watson IoT Platform Connect

3. Predictive Analytics evaluates equipment status and operations providing early warning

4. Machine Learning models continually sweep for non-obvious patterns

5. Watson Explorer harvests insights from documents, manuals and correspondence

6. Visualizations are immediately updated displaying asset early warning

7. Watson IoT Equipment Advisor assists with interactive diagnostics and manual data mining

8. Watson IoT Equipment Advisor collects response effectiveness to enhance corpus & machine learning models

Mines maintenance logs, equipment manuals, technician unstructured data to assist with diagnostics via an interactive dialog to make repair recommendations with the highest probability of success including parts and tooling.
Summary

• Industry 4.0 vision is to boost efficiency of complex product manufacturing
  • Using end to end product integration: digital twins and threads
  • Integration of engineering and manufacturing with the enterprise
  • Leveraging sensors and IoT to continuously collect data
  • Using advanced analytics to increase efficiency and throughput
  • Use cognitive technology to assist operators and workers

• IBM offers key capabilities to support that
  • Integration capabilities, digital twins and threads
  • IoT platform to ingest and monitor relevant data
  • Advanced analytics to optimize assets and processes
  • Cognitive technology to assist engineers and workers
Product complexity is increasing, as are competition and quality standards. Industry 4.0 Initiatives around the world are tackling these challenges using advanced technologies such as the IoT, big data analytics and cognitive computing. This talk describes how the Watson IoT solution stack and ecosystem addresses these needs in areas from continuous product engineering to smart manufacturing. It describes the architecture and key capabilities that transform product creation: model based engineering, horizontal integration to manufacturing, connected manufacturing leveraging connected assets, predictive and cognitive processes, leading to an optimized shop floor. It will also discuss the manufacturing to engineering feedback loop.