Manufacturing Execution Systems and Computer-Enabled Decisions at the Manufacturing System Level

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Dassault Systemes (formerly Apriso)
Manufacturing Execution Systems & Computer-enabled Decisions at the Manufacturing System Level

1. Introduction
2. The Apriso FlexNet: A Process-centric Approach to Manufacturing
4. Driving Towards “Intelligent” BPM & Manufacturing Systems
History Manufacturing Excellence Methodologies
Focused on Process for Decades

Manufacturing Execution System 101 – the Standards View

- **Level 5**: Corporate Performance
- **Level 4**: Business Logistics
  - Plant Production Scheduling, Shipping, Receiving, Inventory, etc.
- **Level 3**: Manufacturing Operations Management
  - Dispatching, Detailed Production Scheduling, Production Tracking, etc.
- **Level 2**: Batch Production Control
- **Level 1**: Continuous Production Control
- **Level 1**: Discrete Production Control

**Timeframe**
- Years
- Quarters
- Months
- Weeks
- Days
- Days
- Shifts
- Hours
- Minutes
- Seconds
- Hours
- Minutes
- Seconds
- Sub-seconds
The Global Manufacturing Challenge …

… to achieve:

- Uniform processes
- Simplified, rationalized IT systems
- Real-time visibility & operational intelligence
- Holistic traceability
- End-to-end process synchronization
Key is to Integrate Manufacturing Globally

- Adapt to shifting demand patterns and supply chains
  - Ensure traceability across supply & partner networks
  - Develop & share best practices
  - Support multiple manufacturing models
  - Maintain simplified, affordable IT support
  - Balance local vs. global processes
  - Manage multi-lingual & multi-time zones
- Remain vendor agnostic in systems, equipment, processes
...And Connect Manufacturing Performance to Business Outcomes

“The Hierarchy of Manufacturing Metrics helps connect manufacturing’s performance with supply chain.”

Gartner
What if we...

- Could have a global manufacturing platform, across your enterprise, that provides visibility, control, and synchronization of your global manufacturing operations?
  - And still enable plant specific extensions?

“This Buyers are shifting focus from site-level applications to broader, multiple-site MES architectures to drive increased responsiveness and flexibility in product supply. Legacy MES investments prohibit this realization.”

Rethinking that MES Investment

Gartner
Enter FlexNet: More Than Just a MES

- A global manufacturing platform providing:
  - Visibility into
  - Control over
  - Synchronization across global multi-site operations

- Application footprint across all mfg operations:
  - Production
  - Quality
  - Warehousing
  - Maintenance
  - Time & Labor
  - Supply Chain Visibility

- Natively Based on a Platform with a:
  - Unified Architecture
  - Unified Processes
  - Unified User Interface
  - Unified Data Model
The FlexNet Platform: “BPM” Centric

- Native Business Process Management
- Built on a Unified Data Model
- Service Oriented Architecture (SOA) from the start

“Vendors such as Apriso exemplify a new generation of manufacturing application framework that blur the boundaries between SCADA, MES, and supply chain execution. They are architected to lower the cost of multi-site rollouts…”

Gartner
Composing Applications Based on Explicit Models of Processes

A key feature allowing BPMs to directly execute modeled processes
Configuration Tables and build variation definition in NG-MES

Line Scheduling/Resequencing

Line Set station with Block Set Station

Work station operations

Repair Station

Sub-assembly management

Part Kitting

Bulk Picking

In-process Cycle:
1. Display Engine information
2. Display of parts to be Assembled at WS
3. Display alerts, QA check list, comments
4. Scanning of Lot / serial no
5. Scanning of Part no.
6. Defect posting
7. Unintentional short build
8. Repair screen
9. Submit maintenance request
10. Request assistance
11. View active deviations
12. Overrides
13. Station over cycle time calculation
14. Downtime code collection
15. Engine release from WS
16. Engine status
Computer-enabled Decision Making in Engine Manufacturing – Example

- Engine arrives
- Get Parts List
  - Get Real-Time BOM Deviations
    - Download Torque Failsafes
      - Download Part Bin Failsafes
  - Get Station Alerts
    - Execute Forward Broadcasts
      - Display Quality Alerts
      - Prompt for Kits
  - Show Workstation Screen
  - Validate Input
    - Record Cycle Time
      - Post Genealogy
  - Engine Departs

Operator Interaction
# Embedded Knowledge of Product Directs Component Picking

<table>
<thead>
<tr>
<th>PLC Address</th>
<th>Description</th>
<th>Sample Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>WORD 11</td>
<td>Part Selection 1 Bin number</td>
<td>0008</td>
</tr>
<tr>
<td>WORD 12</td>
<td>Part Selection 2 Bin number</td>
<td>0018</td>
</tr>
<tr>
<td>WORD 13</td>
<td>Part Selection 3 Bin number</td>
<td>0002</td>
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<tr>
<td>WORD 14</td>
<td>Part Selection 4 Bin number</td>
<td>0005</td>
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<td>WORD 15</td>
<td>Part Selection 5 Bin number</td>
<td></td>
</tr>
<tr>
<td>WORD 16</td>
<td>Part Selection 6 Bin number</td>
<td></td>
</tr>
<tr>
<td>WORD 17</td>
<td>Part Selection 7 Bin number</td>
<td></td>
</tr>
<tr>
<td>WORD 18</td>
<td>Part Selection 8 Bin number</td>
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</tbody>
</table>

**PLC Activates Bin Lights According to the BOM for the ESN**

**Operator Picks Components (Sequence Required or Optional)**

**Fail-safe: Improve Quality and Increase Throughput**
Engine Assembly Operator Screen – Happy Path is “Hands-free”

**ESN:** 12345678  **Status:** In-Production  **Build Property:** Stop  **Build SO:** 1234556

Material Alert: Inspect Part Number 12104ES for burrs on threads

Quality Alert: Inspect ECM Module Shop Order 1234556 for correct mounting

### Part List

<table>
<thead>
<tr>
<th>Part No</th>
<th>Qty</th>
<th>Description</th>
<th>Lot/Serial</th>
<th>Part No</th>
</tr>
</thead>
<tbody>
<tr>
<td>12101ES</td>
<td>2</td>
<td>WASHER, PLAIN</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12103ES</td>
<td>3</td>
<td>NUT, REGULAR HEXAGON</td>
<td></td>
<td>WI</td>
</tr>
<tr>
<td>12104ES</td>
<td>4</td>
<td>NUT, HEAVY HEXAGON</td>
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<td>WI</td>
</tr>
<tr>
<td>12105ES</td>
<td>5</td>
<td>NUT, REGULAR HEXAGON JAM</td>
<td></td>
<td>WI</td>
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<tr>
<td>12106ES</td>
<td>6</td>
<td>SCREW, SOCKET SET</td>
<td>&gt;</td>
<td>WI</td>
</tr>
<tr>
<td>12107ES</td>
<td>7</td>
<td>SCREW, HEX FLANGE HEAD CAP</td>
<td>&gt;</td>
<td>WI</td>
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<tr>
<td>12108ES</td>
<td>8</td>
<td>SCREW, SOCKET HEAD CAP</td>
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<td>WI</td>
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<tr>
<td>12114ES</td>
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<td>PIN, CLEVIS</td>
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<td>WI</td>
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<td>13</td>
<td>SCREW, HEXAGON HEAD CAP</td>
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<td>WI</td>
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</tbody>
</table>

### Comments

- **Part No:** 12101ES  **Comment:** Torque Alternator Pulley Nut to 100 NM
- **Part No:** 12103ES  **Comment:** Bent Diptube fitted to central hole
- **Part No:** 12104ES  **Comment:** Make sure ECM is mounted properly

**Goal:** 223  **Actual:** 23  **Std Cyc Time:** 100  **Op:** DEP1  **Customer:** Komatsu UK

- Defect  - S.Build  - Repair  - Maint  - Assist  - Deviation  - Diagnostic  - New Lot  - Logout  - Release
Engine Assembly Example: Lessons Learned

- Standardized Interfaces to Control Systems
  - Standard control map and functionality for all PLC's
  - Enabling greater flexibility

- Incorporate Computer Decision-making in the MES Layer for Reusability
  - Torque value download
  - Part selection order failsafes (pick-to-light)
  - Previous step(s) complete validation
  - Resulting in improved throughput, and improved quality

- Enabled Multi-site Standardization of Processes
  - Reusable best practices down to the control layer
  - Facilitates continuous improvement
  - Faster and less costly global rollouts
Applying Pattern Recognition to Improve Processes

Key messages:

- Simple, intuitive data analysis user interface tailored for process engineers (not just for PhDs)
- Expertise of process engineers is leveraged and capitalized to supplement automatic rule discovery
- Quality risks are detected and production workers receive recommendations to mitigate them
- Knowledge gained drives process improvement efforts

- Process Mapping
- Study Creation
- Load data
- Process Rules Discovery
- Automatic Learning
- Rule Edition
- Operations Advisor
- Performance Tracker
- Risk Avoidance
- Reports on Rule Usage
- Publication
Can you See Patterns?

<table>
<thead>
<tr>
<th>Duration</th>
<th>Pressure</th>
<th>Temperature</th>
<th>Tool</th>
<th>QUALITY</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Tool 1</td>
<td>OK</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Tool 2</td>
<td>NOT OK</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Tool 1</td>
<td>OK</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Tool 1</td>
<td>NOT OK</td>
</tr>
</tbody>
</table>
Opportunity: Adding Process Rule Discovery to the BPM Platform

“Process Rules Discovery uses pattern-recognition to extract best practice information from process and product characteristics”

**Key Capabilities**

- Closes the loop between Engineering, Production and Quality
- 100% Based on Facts using past performance as the input data set.
- More flexible than tradition statistical methods as missing data is not a problem.
- Determines patterns for multiple outcomes, e.g. good, marginal, and bad.
- Applicable to all types of processes that have multiple data elements that are input to a conclusion.
Driving Towards “Intelligent” BPM & Manufacturing Systems

Raw Intelligence (I)
1 Expected
2 Event & Patterns
3 Poly analytics
4 Machine Learning
5 Directional

Social Intelligence (S)
1 Collaboration
2 Skills Driven
3 Crowd Source
4 Social Analysis
5 Better Practices

Agility (A)
1 Parameters
2 Policies
3 Sequences
4 Milestones
5 Goals

Autonomy (A)
1 Programmed
2 Permitted
3 Notify
4 Constraints
5 Interactive

Visualization (V)
1 Push
2 Subscribe
3 Warn
4 Simulate
5 Gamify

Source: Business Process Management: The Next Wave
Thank You!