RFID & IoT Sensors in Manufacturing

Deployment Guide
RFID and IoT Sensors are being widely deployed in multiple industries for asset tracking and process improvement, within manufacturing facilities, distribution centers, aftermarket service and elsewhere across the value chain. With the advent of ruggedized tags and automated process flows, RFID and IoT benefits can also be extended to harsh environments such as autoclaves, clean rooms, and outdoor maintenance facilities.

But where to start? This guide is designed to help you determine where RFID and IoT technology can have the most impact on process improvement within your manufacturing operation. Based on the thousands of sites where OAT has deployed RFID and IoT solutions, we can anticipate some of the questions you may have when evaluating the technology.

These topics are covered in the following pages.

► How is RFID being used in my industry? Page 3
► What’s driving RFID & IoT Sensor adoption in manufacturing? Page 4
► How do manufacturers measure the ROI of RFID/IoT Projects? Page 5
► How do I build a sensor infrastructure to leverage RFID, RTLS and IoT? Page 6
► What criteria should be used when evaluating tags? Page 7
► How does sensor data integrate with Systems of Record? Page 8
► What criteria should be used when evaluating RFID/IoT Processes? Page 9
► What are the most common Sensors and RFID & IoT-enabled business processes in each functional area? Pages 10-18
  ▶ Logistics Use Cases
  ▶ Materials Management Use Cases
  ▶ Manufacturing Operations Use Cases
  ▶ Aftermarket Services Use Cases

Note: RFID and IoT Sensors include Passive & Active RFID, NFC, Location-Based (GPS, Wi-Fi) Sensors, Security/Authentication sensors, M2M (Machine to Machine sensors, PLCs, Stacklights), Barcode and Application-Specific Sensors.
The following table lists some of the most common industry-specific business processes for RFID in Manufacturing.

### INDUSTRY-SPECIFIC BUSINESS CASES

<table>
<thead>
<tr>
<th>Industry:</th>
<th>RFID Applications:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aerospace &amp; Defense</td>
<td>• Tool/Tooling Tracking</td>
</tr>
<tr>
<td></td>
<td>• ATA 2000 Part Marking</td>
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<tr>
<td></td>
<td>• Composite Material Tracking</td>
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<td>• Work Order Tracking</td>
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<td>Apparel</td>
<td>• Source-to-Store Tracking</td>
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<td></td>
<td>• Omni-channel Fulfillment</td>
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<td>• Bulk Commissioning</td>
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<tr>
<td>Automotive</td>
<td>• Warranty/Recall Tracking</td>
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<td></td>
<td>• Kanban Management</td>
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<td></td>
<td>• Line-Side Replenishment</td>
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<td></td>
<td>• Yard Management</td>
</tr>
<tr>
<td>Chemicals</td>
<td>• Hazardous Material Tracking</td>
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<td></td>
<td>• Container Pedigree</td>
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<tr>
<td></td>
<td>• Batch Tracking</td>
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<tr>
<td>Consumer Products</td>
<td>• Source-to-Store Tracking</td>
</tr>
<tr>
<td></td>
<td>• Warranty/Recall Tracking</td>
</tr>
<tr>
<td></td>
<td>• Batch Tracking</td>
</tr>
<tr>
<td>Food &amp; Beverage</td>
<td>• “Farm to Fork” Tracking</td>
</tr>
<tr>
<td></td>
<td>• Expiration Date Tracking</td>
</tr>
<tr>
<td>Industrial Machinery</td>
<td>• WIP, Whole Goods Tracking</td>
</tr>
<tr>
<td></td>
<td>• Kitting and Shipping</td>
</tr>
<tr>
<td></td>
<td>• Tooling Tracking</td>
</tr>
<tr>
<td>Medical Devices / Biotech</td>
<td>• Clean Room Tracking</td>
</tr>
<tr>
<td></td>
<td>• Indirect Material Tracking</td>
</tr>
<tr>
<td></td>
<td>• Clean Manufacturing WIP</td>
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<td></td>
<td>• Lab Equipment Tracking</td>
</tr>
<tr>
<td></td>
<td>• Reverse Logistics</td>
</tr>
<tr>
<td>Oil &amp; Gas</td>
<td>• Equipment Tracking</td>
</tr>
<tr>
<td></td>
<td>• Indirect Material Tracking</td>
</tr>
<tr>
<td></td>
<td>• Personnel Tracking</td>
</tr>
<tr>
<td>Pharmaceuticals</td>
<td>• Source-to-Store Tracking</td>
</tr>
<tr>
<td></td>
<td>• Batch Tracking</td>
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<tr>
<td></td>
<td>• e-Pedigree</td>
</tr>
<tr>
<td></td>
<td>• Controlled Substance Tracking</td>
</tr>
</tbody>
</table>

### CASE STUDY: WORK-IN-PROCESS TRACKING

A Heavy Equipment Manufacturer had significant inventory of “95% complete” orders. Missing a single part or requiring rework, these orders were not contributing to revenue, but tying up inventory, warehouse space and working capital along with customer orders.

The company worked with OAT to RFID-enable its SAP ERP system, gaining up-to-the minute visibility into Work-in-Process, materials inventory and finished goods. As a result, errors and rework have virtually been eliminated, while reducing labor and inventory costs and speeding delivery to customers.
Key Drivers for Sensor Adoption in Manufacturing

Manufacturing Operations have common characteristics across industries:

- Significant investment in capital assets
- Core processes are either customer-facing or contract-driven
- Recent advances in materials, processes and technology
- High operational and regulatory risk
- High business complexity

These factors are driving the adoption of RFID and IoT Sensors.

PRIMARY DRIVERS OF RFID & IOT SENSORS IN MANUFACTURING

**Working Capital Allocation**
CFOs are putting capital asset inventory under scrutiny since working capital allocation is a prime component of operating profit – enterprises need additional visibility to proactively manage these assets across multi-facility manufacturing and aftermarket service operations.

**External Stakeholders**
Large scale projects require more resources and more tightly managed processes, as stakeholders (customers, suppliers, shareholders) demand transparency throughout the program, not just at program completion.

**Quality, Safety & Compliance**
With increased focus on quality, safety and program compliance, flagging errors and exceptions at the process level is more important than ever.

**Process Efficiency**
Lean initiatives are gaining importance in manufacturing, logistics and service operations. As organizations are asked to increase throughput with existing resources, process automation becomes a priority.
Measuring ROI for RFID / IoT Manufacturing Deployments

The ROI of sensor deployments in Manufacturing generally centers around a high-impact business case, that is, a clearly-defined operational process that is directly related to the bottom line, or the management of large asset categories on the balance sheet. Automating a high impact business process (especially one that is manual, costly and inefficient) with RFID or IoT Sensors increases not just asset visibility, but the visibility of the project itself – which can lead to more corporate resources and support for your deployment. Some of the most common metrics are listed below.

**COMMON ROI METRICS FOR RFID & IOT DEPLOYMENTS - MANUFACTURING**

<table>
<thead>
<tr>
<th>ROI Metric</th>
<th>Related to</th>
<th>How it is Calculated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduction in Equipment/ Tooling/ Indirect Material Inventory</td>
<td>Working Capital Allocation</td>
<td>Buffer inventory of tooling, equipment to compensate for missing or out-of-spec tools, as a percentage of overall inventory</td>
</tr>
<tr>
<td>Increase in Labor Utilization</td>
<td>Process Efficiency</td>
<td>Average labor rate and # of employees involved with equipment tracking, multiplied by % of non-value added activities - locating tools, locating service history and specific work instructions</td>
</tr>
<tr>
<td>Improved Asset Utilization</td>
<td>Working Capital Allocation</td>
<td>Redundant inventory of capital assets, assets that have not been used in &gt;6 months or duplicate inventory</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Percentage of capital assets not being utilized - missing or under repair</td>
</tr>
<tr>
<td>Improved On-Time Performance Reduced Schedule Risk</td>
<td>Process Efficiency</td>
<td>Reduction in days outstanding for accounts receivable</td>
</tr>
<tr>
<td></td>
<td>External Stakeholders</td>
<td>Reduction in revenue recognition delays</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Customer make-goods, discounting to make up for late orders</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fines for breach of contract</td>
</tr>
<tr>
<td>Improved Process Tracking Reduced Quality Risk</td>
<td>Process Efficiency</td>
<td>Reduction in rework costs</td>
</tr>
<tr>
<td></td>
<td>Quality, Safety &amp; Compliance</td>
<td>Customer make-goods, discounting to make up for quality issues</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Reduction in out-of-spec equipment and tooling</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fines for non-compliance based on quality errors</td>
</tr>
</tbody>
</table>
Building a Sensor Infrastructure

Sensors are proliferating in manufacturing plants, in the supply chain, and for consumer applications. Building a sensor infrastructure to capture, contextualize, normalize and act on sensor events is basically an extension of how RFID sensors are managed today.

**4 INGREDIENTS FOR MAKING SENSORS (IOT, RFID, RTLS) WORK IN MANUFACTURING**

1. **Common Sensor Platform**
   - To integrate information from people, processes and devices

2. **Sensor Data Management**
   - To infer data relevance and business context

3. **Process Compliance**
   - To ensure data quality and exception handling from thousands of sensors

4. **Actionable Information**
   - To provide real-time alerts and integration with systems of record

**TYPES OF SENSORS**

- **RFID / NFC**
  - Radio Frequency Identification, including Near Field Communication
  - Location-Based (RTLS, GPS)
  - RTLS, Wi-Fi, GPS used for indoor & outdoor applications
  - Security/Authentication
  - often seen at entrances & exits and at Point of Sale in retail settings (e.g., RF EAS)

- **M2M**
  - Machine-to-Machine communication and devices

- **Barcode**
  - Auto-ID standard for many decades – updated functionality and enhanced data through 2D/3D barcodes

- **App Specific**
  - Designed for specialized applications (e.g. medical implants, remote maintenance)
Selecting Tags

The first consideration most companies have when deploying RFID/IoT Sensors in manufacturing is finding suitable tags that can perform well for the materials being tagged and the environmental conditions of the process being tracked. Common criteria for tag selection is listed below:

A CHECKLIST FOR TAG SELECTION IN MANUFACTURING OPERATIONS

- Will the tag be used outdoors or indoors? (many companies use a combination of tags to balance price/performance)
- What temperature range will the tag be used in?
- Is the asset in a pressurized/ depressurized environment?
- What material are the assets made of? Is the manufacturing process high value? High volume?
- How will the tags be attached to the asset? How long will the asset be in service? Are there special considerations for adhesives, mounting hardware?
- How large are the assets to be tagged? Are the assets curved or unusually shaped?
- Will the asset be exposed to harsh chemicals or bioburden? Do tags need to be flush-mounted to facilitate cleaning/sterilization?
- Will the tags be used across international borders? Are there additional regulations/operating requirements to consider?
- Will the tags be exposed to radiation, or be stored in the same facility as explosive materials?
- Will the assets be source tagged at time of manufacture? Will high-speed tagging and encoding be integrated into manufacturing or DC processes?
ERF, WMS, MMS, MRO, Field Service Management and Asset Management systems are the lifeblood of many manufacturing and logistics operations. RFID and IoT-enabling enterprise systems incorporate real-time production and delivery status into day-to-day business metrics. This enables manufacturers, logistics and service providers to uncover and address process errors before they impact production schedules, product quality or customer deliveries.

Enterprise systems can also provide a built-in process framework for your RFID project, reducing deployment time and decreasing time to value.

The following table includes common integration scenarios:

<table>
<thead>
<tr>
<th>ERP</th>
<th>Enterprise Resource Planning</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Verify physical components against bill of materials</td>
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<tr>
<td></td>
<td>Trigger inventory replenishment</td>
</tr>
<tr>
<td></td>
<td>Locate missing parts &amp; equipment</td>
</tr>
<tr>
<td></td>
<td>Flag and expedite critical work orders</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>MES</th>
<th>Manufacturing Execution</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Track physical products at each stage of testing and assembly</td>
</tr>
<tr>
<td></td>
<td>Confirm custom orders match manifest</td>
</tr>
<tr>
<td></td>
<td>Locate missing parts &amp; equipment</td>
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</tbody>
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<table>
<thead>
<tr>
<th>WMS</th>
<th>Warehouse Management</th>
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<tbody>
<tr>
<td></td>
<td>Verify manifest and destination for outgoing shipments</td>
</tr>
<tr>
<td></td>
<td>Prevent mis-shipments with visual/audible alarms</td>
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<tr>
<td></td>
<td>Track finished goods inventory and location</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>MRO</th>
<th>Maintenance &amp; Repair Operations</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Verify parts &amp; equipment against service order</td>
</tr>
<tr>
<td></td>
<td>Monitor installation and maintenance history</td>
</tr>
<tr>
<td></td>
<td>Locate recalled or expired service parts</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>MMS</th>
<th>Materials Management</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Verify parts &amp; equipment against service order</td>
</tr>
<tr>
<td></td>
<td>Monitor installation and maintenance history</td>
</tr>
<tr>
<td></td>
<td>Locate recalled or expired service parts</td>
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</table>

<table>
<thead>
<tr>
<th>Program Management</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Verify parts &amp; equipment against service order</td>
<td>Monitor installation and maintenance history</td>
</tr>
<tr>
<td>Locate recalled or expired service parts</td>
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</tbody>
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<table>
<thead>
<tr>
<th>BAM</th>
<th>Business Activity Monitoring</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Automatically update dashboards to reflect real-time:</td>
</tr>
<tr>
<td></td>
<td>Physical inventory levels</td>
</tr>
<tr>
<td></td>
<td>Orders shipped</td>
</tr>
<tr>
<td></td>
<td>Operational efficiency</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>EAM</th>
<th>Enterprise Asset Management</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Instantly locate physical assets across the value chain</td>
</tr>
<tr>
<td></td>
<td>Monitor service maintenance history</td>
</tr>
<tr>
<td></td>
<td>Manage compliance and audit requirements</td>
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</tbody>
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<table>
<thead>
<tr>
<th>Field Service Management</th>
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</thead>
<tbody>
<tr>
<td>Confirm parts inventory requirements, truck manifests for service orders</td>
<td>Monitor tool usage and maintenance history</td>
</tr>
<tr>
<td>Locate recalled or expired service parts</td>
<td></td>
</tr>
</tbody>
</table>
Selecting Processes

Deploying RFID/IoT Sensors in a manufacturing environment requires a thorough evaluation of “environment-ready” and “material-ready” tags and hardware. Selecting high-impact processes that deliver bottom-line results to the organization is equally important. Criteria for high-impact processes is listed below:

A CHECKLIST FOR HIGH-IMPACT PROCESSES IN MANUFACTURING

- Does the current business process have well documented costs or metrics associated with it?
- Is the process related to a high-visibility program or project for the organization?
- Does the process ultimately interact with the end customer?
- Are there regulatory requirements or contract requirements associated with the process?
- Does the outcome of this process impact revenue or costs on the company’s income statement?
- Do the assets associated with this process impact the company’s balance sheet?
- Are the assets associated with a new fabrication process or materials?
- Does the company incur significant risk if the process is non-compliant?
- Are there a significant number of capital assets or single-source assets associated with this process?
This guide lists RFID use cases by process area, although there are use cases which span all aspects of manufacturing. For example, capital goods may be assembled across multiple facilities, with one plant specializing in metal fabrication another in advanced composites, and another in final assembly. Plants may be located miles apart, hundreds of miles apart, even in separate countries. This changes the definition of Work-in-Process tracking from recording when a job moves from work station to work station, to tracking subassemblies as they move from facility to facility – it’s RFID-enabled shipping and receiving.

### Process Areas:

#### Logistics
- **Sensors & Use Cases:**
  - RFID / NFC
  - Location-Based (RTLS, GPS)
  - Barcode
  - Kitting & Shipping
  - RTI (Returnable Transport Item) Tracking
  - Inbound Receiving

#### Materials Management
- **Sensors & Use Cases:**
  - RFID / NFC
  - Location-Based (RTLS, GPS)
  - Barcode
  - Composite Material Tracking
  - Indirect Materials Management
  - Tool & Equipment Tracking

#### Manufacturing Operations
- **Sensors & Use Cases:**
  - RFID / NFC
  - Location-Based (RTLS, GPS)
  - Barcode
  - Work-in-Process Tracking
  - Kanban Management / Cycle Counting
  - Work Order Tracking

#### Aftermarket Services
- **Sensors & Use Cases:**
  - RFID / NFC
  - Location-Based (RTLS, GPS)
  - Barcode
  - M2M
  - Line-Side Maintenance
  - Overhaul Operations
  - Yard Management
Logistics: RFID & IoT Applications

The following table lists some of the most common use cases for RFID and RTLS in Logistics Operations. Sample process flows are illustrated on the next page.

<table>
<thead>
<tr>
<th>Application:</th>
<th>RFID/ IoT Process Automation:</th>
<th>Enterprise Systems Integration Options:</th>
<th>RFID/ IoT Value-Add:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kitting &amp; Shipping</td>
<td>▪ Automated Data Entry for Component Manifest, Shipping Manifest, ASN</td>
<td>ERP, Project Management, WMS Systems:</td>
<td>▪ Error-proofing kitting and shipping process</td>
</tr>
<tr>
<td></td>
<td>▪ Verifying outgoing orders</td>
<td>▪ Compare outgoing goods with Component Manifest/Shipping Manifest</td>
<td>▪ Significantly reduce misshipments, customs delays and costly correction processes</td>
</tr>
<tr>
<td></td>
<td>▪ Expediting rush orders</td>
<td>▪ Compile customs documentation based on component part history records, work orders, customer requirements</td>
<td>▪ Focusing staff on fulfilling orders vs. managing paperwork</td>
</tr>
<tr>
<td></td>
<td>▪ Automated customs documentation for international shipments</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RTI (Returnable</td>
<td>▪ Tracking reusable containers and contents from location to location</td>
<td>ERP, Project Management, WMS Systems:</td>
<td>▪ Automated check-in/check-out processes</td>
</tr>
<tr>
<td>Transport Item)</td>
<td>▪ Tracking Container Pedigree when hazardous materials are involved</td>
<td>▪ Pull parts manifest for each work order to track components</td>
<td>▪ Real time status of work orders and components</td>
</tr>
<tr>
<td>Tracking</td>
<td></td>
<td>▪ Confirm final destination for each shipment &amp; work order number</td>
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<tr>
<td></td>
<td></td>
<td>▪ Alert staff with a visual or audible alarm when a work order is received in the wrong location</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inbound Receiving</td>
<td>▪ Automated Receipt, Verification of Goods</td>
<td>ERP, Project Management, WMS Systems:</td>
<td>▪ 100% Automated Tracking &amp; Reliable Identification of Shipments as they are Received</td>
</tr>
<tr>
<td></td>
<td>▪ Expediting Rush Orders</td>
<td>▪ Compare Received Goods with Content Manifest or ASN</td>
<td>▪ Focusing Staff on Exception Handling vs. Administrative Paperwork</td>
</tr>
<tr>
<td></td>
<td>▪ Quarantining and Tracking Non-scheduled Shipments</td>
<td>▪ Flag Rush Orders by Comparing Order Number and Special Instructions</td>
<td></td>
</tr>
</tbody>
</table>

Example

Inbound Receiving:
An Aerospace OEM worked with OAT to automate receipt of shipments from Component Suppliers, resulting in a significant reduction in handling time and labor costs

▪ Auto-ID Technology: RFID, Wi-Fi, Barcode
▪ Enterprise Systems: SAP, Baan ERP
Logistics: Functional Process Flows

Example: Shipping

ERP / WMS System
- Get Order Details from ERP/WMS
- Assign/schedule delivery to site
- Execute ERP/WMS transactions (update goods issue, send ASN, etc.) and capture event data

OATxpress™
- Get delivery manifest details for dock door 17
- Validate against manifest
- Send manifest fulfillment details

OATdevice manager™
- Final inspection at dock door 17
- Read package, asset, contents
- Operator feedback

Auto-ID Devices & Sensors
- RTLS, UWB, Wi-Fi, Barcode, Active/Passive RF, Alarms...

Example: Receiving

ERP / WMS System
- Get Order Details from ERP
- Assign/schedule delivery to site
- Execute ERP transactions (update goods issue, send ASN, etc.) and capture event data

OATxpress™
- Get delivery manifest details for dock door 4
- Validate against manifest
- Send manifest fulfillment details

OATdevice manager™
- Receipt at dock door 4
- Read package, asset, contents
- Operator feedback

Auto-ID Devices & Sensors
- RTLS, UWB, Wi-Fi, Barcode, Active/Passive RF, Alarms...

MANIFEST CONFIRMED
Ready for Shipment at Dock Door 017

MANIFEST NOT CONFIRMED
Shipment Does NOT match manifest. Verify with Shipper
## Materials Management: RFID & IoT Applications

The following table lists some of the most common use cases for RFID and IoT in Materials Management. Sample process flows are illustrated on the next page.

<table>
<thead>
<tr>
<th>Application:</th>
<th>RFID/ IoT Process Automation:</th>
<th>Enterprise Systems Integration Options:</th>
<th>RFID/ IoT Value-Add:</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Composite Material Tracking</strong></td>
<td>- Tracking Freezer Out-Time for Perishable Materials</td>
<td>ERP, Material Management Systems (MMS)</td>
<td>- Reduction in Scrap Material</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Monitor Out-time while Material is in Cutting, Layup stages</td>
<td>- Reduction in Quality Risk</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Alert Staff When Out-Time Threshold is Imminent</td>
<td></td>
</tr>
<tr>
<td><strong>Indirect Materials Management</strong></td>
<td>- Real-time Tracking of Indirect Materials used in Manufacturing and Transport</td>
<td>ERP, Project Management, WMS Systems:</td>
<td>- Immediate Location of Conveyances Reduces Shipping Delays</td>
</tr>
<tr>
<td>- Molds</td>
<td></td>
<td>- Verify and Update Location and Status of Molds, Jigs and Conveyances</td>
<td>- Reduction in Spares Inventory</td>
</tr>
<tr>
<td>- Jigs</td>
<td></td>
<td>- Pre-stage specific materials for each Work Order</td>
<td>- Reduced Quality Risk from Molds Exceeding Duty Cycles</td>
</tr>
<tr>
<td>- Conveyances</td>
<td></td>
<td></td>
<td>- Audit Trail of Right-to-Use Equipment</td>
</tr>
<tr>
<td><strong>Tool &amp; Equipment Tracking</strong></td>
<td>- Real-time Tracking of Tooling and Specialized Equipment</td>
<td>ERP, Project Management, WMS Systems:</td>
<td>- Automated Inventory Management</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Verify and Update Tool Location and Maintenance Records when Tools are checked in and out</td>
<td>- Reduction in Tool Spares</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Fewer Lost Tools, Increasing Manufacturing Uptime</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Audit Trail of Tool Usage and Maintenance Simplifies Compliance</td>
</tr>
</tbody>
</table>

### Example

**Tool Tracking:**
A Fortune 500 Defense Contractor worked with OAT to track specialized Tools and Tooling across a 20+ building manufacturing campus to improve asset utilization and reduce tool inventory.

- **Auto-ID Technology:** RFID, Barcode
- **Enterprise Systems:** Deltek CostPoint
Example: **Tool Tracking**

**ERP / WMS / MRO System**
- Get tool/equipment serial # and calibration schedule from ERP /MES/ Service & Maintenance
- Assign tool to operator/location for specific time period
- Update tool maintenance schedule

**OATxpress™**
- Get location details for tool store
- Validate against inventory/calibration table
- Send maintenance details to All

**OATdevice manager™**
- Reception at tool store
- Read tool, operator ID, location
- Operator feedback

**Auto-ID Devices & Sensors**
- RTLS, UWB, Wi-Fi, Barcode, Active/Passive RF, Alarms...

**Alert!**
Tool# 75622 Requires Calibration Please Service

Example: **Composite Materials Tracking**

**MMS / ERP / WMS System**
- Update system with time/date of receipt, batch #, mfr
- Start tracking freezer out-time based on mfr recommendations
- Decrement freezer out time

**OATxpress™**
- Record receipt of material
- Record material movement
- Confirm out time counter

**OATdevice manager™**
- Receive perishable composite material, place in storage freezer with time/date stamp
- Remove material from freezers for layup process
- Operator feedback at freezer

**Alert!**
310 out of 400 hours of freezer out time have elapsed. Use batch #2789 immediately

**Auto-ID Devices & Sensors**
- RTLS, UWB, Wi-Fi, Barcode, Active/Passive RF, Alarms...
Manufacturing: RFID & IoT Applications

The following table lists some of the most common use cases for RFID and IoT in Manufacturing Operations. Sample process flows are illustrated on the next page.

<table>
<thead>
<tr>
<th>Application:</th>
<th>RFID/ IoT Process Automation:</th>
<th>Enterprise Systems Integration Options:</th>
<th>RFID/ IoT Value-Add:</th>
</tr>
</thead>
</table>
| Work-in-Process Tracking | Real-time Tracking of Manufacturing Work Orders, Component Parts & Subassemblies | ERP, MES, Project Mgmt. Systems  
- Update Inventory Levels and Component Parts at each Step of the Assembly Process  
- Alert Operator or Replenish Part Stores when Inventory Levels fall below a Pre-Defined Threshold | 100% Automated Tracking & Reliable Identification of Work Orders through the Manufacturing Process  
- Reduction in Safety Stock and Reusable Containers  
- Help Prevent Missing Orders and Rework, Increasing Manufacturing  
- Audit Trail of Components, Batch Numbers for Finished Products |
| Kanban Management | Proactive Inventory Management & Automatic Replenishment | ERP, Project Management, WMS Systems:  
- Compare Expected Inventory with Actual Inventory  
- Alert Operator or Replenish when Inventory Levels are Low | Automated Stock Taking and Replenishment  
- Reduction in Safety Stock, Labor Costs |
| Cycle Counting | Real-time Tracking of Customer Work Orders | ERP, MES, Project Mgmt. Systems  
- Update Component Part Inventory as Custom Components are Assigned to Work Orders.  
- Pre-stage Materials, Tooling and Indirect Materials for Custom Work Orders | Tracking Visibility of Customer Orders at Each Stage of the Assembly and Finishing Process  
- Fewer Substitutions, Rework and Rush Shipments Due to Missing Components  
- Improved Customer Satisfaction  
- Documented Audit Trail of Components, Batch Numbers for Finished Products |

Example

Work Order Tracking
A Specialized Aircraft Manufacturer worked with OAT to track subassemblies and whole goods being shipped directly to customers, resulting in reduced costs for outbound shipping and reduced labor costs for preparing customs paperwork
- **Auto-ID Technology**: RFID, Barcode
- **Enterprise Systems**: SAP ERP
Example: **Kanban Management / Cycle Counting**

**ERP / WMS System**
- Get expected inventory levels from ERP/WMS
- Get specific inventory levels for Component Store #2
- Get assembly instructions and component list for workstation #3
- Assign work order to operator

**OATxpress™**
- Decrement inventory levels in ERP System and/or Kanban board
- Validate against actual inventory
- Validate against Work Order
- Read component serial #s, batch #s, test data
- Receipt at workstation #3

**OATdevice manager™**
- Trigger inventory replenishment for low stock items
- Send work order status
- Operator feedback
- Read component serial #s
- Operator feedback

**Auto-ID Devices & Sensors**
- RTLS, UWB, Wi-Fi, Barcode, Active/Passive RF, Alarms...
- Cycle count items in Component Store #2
- Alert! Minimum Stock Level For Part AST7090 Auto-Replenishment Order in Process
- Alert! Part # TR783-065 is Recalled. Please Substitute with Part# CR782-0621
- Alert! Minimum Stock Level For Part CR782-0621

Example: **Work-in-Process Tracking**

**ERP / WMS System**
- Get Work Order details from ERP/MES
- Execute ERP transactions (update component inventory, work order status) & capture event data to OER

**OATxpress™**
- Assign work order to operator
- Validate against Work Order
- Get expected inventory levels from ERP/WMS
- Read component serial #s, batch #s, test data

**OATdevice manager™**
- Execute ERP transactions
- Operator feedback
- Alert! Part # TR783-065 is Recalled. Please Substitute with Part# CR782-0621

**Auto-ID Devices & Sensors**
- RTLS, UWB, Wi-Fi, Barcode, Active/Passive RF, Alarms...
# Aftermarket Services: RFID & IoT Applications

The following table lists some of the most common use cases for RFID and IoT in Aftermarket Services, including line maintenance, overhaul and the management of trailer yards. Sample process flows are illustrated on the next page. Note that Overhaul Operations is similar to Work-in-Process tracking illustrated on page 9.

<table>
<thead>
<tr>
<th>Application</th>
<th>RFID/ IoT Process Automation</th>
<th>Enterprise Systems Integration Options</th>
<th>RFID/ IoT Value-Add:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Line-Side Maintenance</td>
<td>• Automated parts replenishment and service documentation for line-side maintenance</td>
<td>ERP, MRO, Service &amp; Asset Mgmt. Systems</td>
<td>• Increased time in service</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Compare maintenance schedule and service parts against current service history, update history as service is performed</td>
<td>• Reduced labor costs for managing administrative paperwork, reduced regulatory fines</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Alert operator to components which need to be checked and replaced</td>
<td>• More efficient labor and parts allocation, reducing overall maintenance and repair costs</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Compare and update physical parts and tool inventory, place replenishment orders when stock runs low</td>
<td></td>
</tr>
<tr>
<td>Overhaul Operations</td>
<td>• Real-time Tracking of M&amp;E Operations such as engine overhaul</td>
<td>ERP, MRO, M&amp;E Systems:</td>
<td>• 100% Automated Tracking &amp; Reliable Identification of Work Orders through the Overhaul Process</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Update Work Order Status as Service is Performed</td>
<td>• Reduce Rework, Labor and Inventory Costs</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Update Inventory Levels and Component Parts are Assigned to New Work Orders.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Alert Operator or Replenish Part Stores when Inventory Levels fall below a Pre-Defined Threshold:</td>
<td></td>
</tr>
<tr>
<td>Yard Management</td>
<td>• Automated tracking and identification of trailers and their contents as they arrive, exit or move within a laydown yard</td>
<td>ERP, Service &amp; Asset Mgmt. WMS Systems:</td>
<td>• Significantly reduced error rates, correction processes and 3rd party service costs</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Compare trailer contents with manifests, ASNs and work orders</td>
<td>• Minimized driver and trailer detention time</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Update inventory and place replenishment orders as needed</td>
<td>• Minimized need for extra trailers, safety stock and expedite costs</td>
</tr>
</tbody>
</table>

## Example

**Engine Overhaul Tracking:**

An International Airline worked with OAT to track components and work-in-process for engine overhaul operations, resulting in increased efficiency, on-time delivery and significant labor savings.

- **Auto-ID Technology**: RFID, Barcode
- **Enterprise Systems**: In-house M&E Application
Aftermarket Services: Functional Process

Example: **Line-Side Maintenance**

**ERP / WMS / MRO System**
- Get BOM Details from MRO System
- Schedule Service Call
- Update Service History, Component Information

**OATxpress™**
- Get Spare Part Details at Service Bay #11
- Validate Against BOM
- Send Service Call Details

**OATdevice manager™**
- Receipt at Service Bay #11
- Read Part Information
- Operator feedback

**Auto-ID Devices & Sensors**
- RTLS, UWB, Wi-Fi, Barcode, Active/Passive RF, Alarms...

**Example: **Yard Management**

**ERP / WMS / Service & Asset Management System**
- Get delivery schedule from ERP / WMS / Service & Asset Management
- Assign finished goods to zone within laydown yard
- Update yard management map

**OATxpress™**
- Get location details for trailer
- Validate against inventory/ location table
- Send configuration details

**OATdevice manager™**
- Receipt at laydown yard
- Read product ID, trailer ID, location
- Operator feedback

**Auto-ID Devices & Sensors**
- RTLS, UWB, Wi-Fi, Barcode, Active/Passive RF, Alarms...

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About OATSystems.

OATSystems solutions are used across 3500 facilities worldwide, helping companies take advantage of RFID and IoT Sensors to streamline operations, enhance customer satisfaction and increase bottom line results. OAT is the recognized Auto-ID solution leader with software that empowers businesses to achieve a competitive advantage and ROI from RFID & IoT Sensors. As a pioneer in the development of Auto-ID technology, OAT has been setting the standard in RFID over the last decade and has provided RFID & IoT-enabled solutions to leading companies such as Airbus, ADAT, BAE Systems, GE, Monsanto, Bell Helicopter, Kohl’s, Inditex, JBC, C&A, VA Health System, OrbitalATK, Cessna, Parker Hannifin, Petrobras, Kimberly-Clark, Teva, Aeon, Rockwell Collins, TAP M&E and others. A division of Checkpoint Systems (NYSE:CKP), OATSystems is located in Waltham, MA, and has a development office in Bangalore, India and various direct sales offices and resellers around the globe.

Contact OATSystems today at www.oatsystems.com or 781-907-6100 and get ready to take control of your operations.

For specific information on Asset Tracking applications visit www.oatsystems.com/asset_tracking/index.php

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