Tracking Unique Parts in an Assembly Environment Using RFID

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ABSTRACT

This project application is designed for a factory that manufactures heavy off-road equipment. Four vehicle assembly lines and five cab assembly lines operate in the factory. The company operating this facility is in the early stages of RFID implementation across the global enterprise. [1] [2] The purpose of this business case is to leverage current and proposed implementations. The use of passive tags to track incoming unique prototype parts from receiving through production is explored. A system architecture for integrating design, supply chain and manufacturing information technology systems with Radio Frequency Identification (RFID) technology is presented.

INTRODUCTION

Product improvement projects generate a set of new parts and assemblies to be used in prototype builds. These parts must be tracked from concept to assembly and must be isolated from the flow of current production parts. Design, manufacturing and assembly engineers, as well as supply management and assembly personnel require access to information associated with these unique parts throughout the design to manufacture process. Radio frequency identification technology offers features that may be applied to reducing man-hours spent in tracking these parts and verifying the bill of materials prior to a prototype build. Attaching RFID tags, effectively making the incoming parts into smart parts, [3] has the potential to reduce man-hours spent tracking unique parts.

1. CASE ENVIRONMENT

1.1 Prototype Part Generation

Product improvement projects generate new prototype designs for existing vehicle configurations. This process generates a new subset of parts. Prototype vehicles are built to verify design concepts and manufacturing processes and to be used in customer feedback field trials. These prototype vehicles are produced on the existing assembly line, interspaced with regular production vehicles.

In the design phase, Pro/Engineer modeling software generates a bill of materials (BOM) for the prototype vehicle builds. The BOM for the new prototype geometry subset is advanced to suppliers to produce the parts, and to production engineers to design or modify the assembly process. Once produced, these unique parts must be segregated from production parts and be available for review by design and assembly engineers in preparation for the prototype build.

An excessive amount of time is spent by production engineers, assemblers and material handlers to locate and track the BOM of incoming prototype parts with new part numbers that are not in the Materials Resource Planning (MRP) system. Inbound prototype parts are segregated from production parts by placement in an isolated prototype part queue area. However, without reference to the new part numbers in the MRP system, inbound prototype parts can be sent to the wrong assembly line or mixed with inbound production parts. When this occurs, it is difficult for prototype parts to be identified and/or located. Verification of the complete BOM of prototype parts ,with lead time before the prototype build, is required to avert a project show stopper or an assembly line stoppage.

This project proposes attaching RFID tags to incoming prototype parts for special projects or mule builds to ensure timely delivery and tracking of the BOM for prototype projects. RFID tags will provide the information needed to route the part to the proper assembly line, attention the proper individual. Once in the assembly queue, the proposed system will verify the BOM before launch. If parts are removed from the queue for inspection, removal and return of the part will be tracked.

Up-front costs would include equipping the target factory receiving areas with readers, integrating software into the existing IT system, and stocking reusable tags to eliminate recurring costs. The proposed RFID system will be used to alert receiving personnel as a prototype part arrives, to notify the originator of the part that the part has arrived at the factory, to sort incoming parts for delivery to the four vehicle assembly lines and to track completion of the BOM before and during the scheduled prototype build. The costs will be assessed against savings in man-hours for an ROI estimate. It should be noted that implementing this system in one of the factories already equipped with gate readers or combining this proposal with other uses of RFID would accelerate the return on investment (ROI). For this reason, two ROI calculations will be proposed.

1.2 Factory Environment

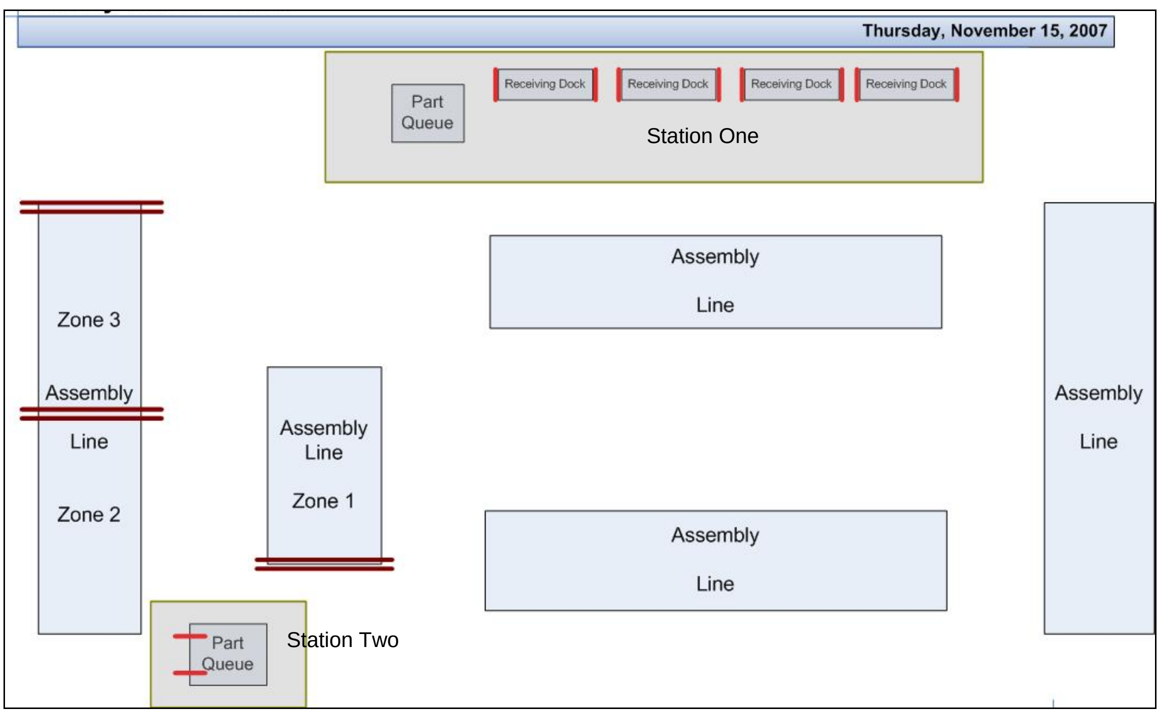

Figure 1 - Factory Environment

Production parts are received at the twelve shipping and receiving dock doors identified in Fig 1 as Station One. Inbound parts are sorted and delivered to the assembly lines. A Kanban system is used for part replenishment, with containers of production parts delivered directly to the proper location adjacent to the assembly line. Prototype parts are not in the Kanban system, and are directed to a Prototype Build queue area set apart from the assembly line, identified in Fig 1 as Station Two. Currently, the inbound prototype parts at Station Two are identified by the package label, and are manually checked against a part list generated by the BOM. This is time consuming, and can generate error. Prototype parts may be removed from the queue for inspection, which is not accounted for on the manual log. For the target module, each prototype build includes four vehicles, representing the four major model types of the product. Prototype parts must be sorted to complete the BOM of four different vehicles. The part number is also correlated with the appropriate operational methods sheet (OMS). These can be accessed on the four computers on the assembly line.

The group of personnel assigned to support each assembly line is identified as a module, and each module maintains a manufacturing database of design, manufacturing and assembly related information. The prototype part numbers are downloaded from Pro/Engineer into the module database. The database tracks the following pertinent information:

1. bill of materials for each prototype build vehicle, typically four vehicles
2. identification of one of sixteen assembly line stations to which each part is assigned
3. assembly operational methods sheets (OMS) assigned to each station

2. RFID SYSTEM ARCHITECTURE

2.1 System Hardware

The proposed closed loop system consists of portal readers, middleware housed in the existing IT intranet to interface with the module database and a permanent supply of RFID tags. The system includes two stations, one at the receiving dock, and one at the assembly line part queue. These are indicated by the light red lines in Fig 1 above.

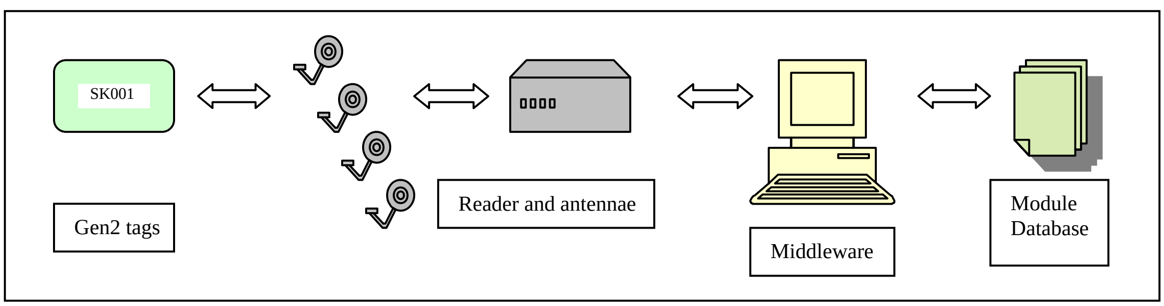

Figure 2 - Structure of Station 1 RFID System

Gen2 passive write-once/read-many (WORM) tags, specified as Alien ALN 9540 Squiggle, see Appendix A, with general identification, GID-96, will be embedded in polycarbonate covers with barcode and alpha-numeric codes. [6] The embedded tags will be durable for reuse, can have a visual ID for reclaim, and can interact with a barcode system as well for greater overall visibility. The visual identification aids in maintaining and sorting the supply of tags in the module. It also assures that the correct tags are sent to each supplier and are attached to the correct incoming parts. The tag in Fig 1 has the code SK001 which identifies the Skidder assembly line, and tag 001 assigned to that line. The associated barcode is not shown. The GID-96 electronic product code illustrated in Fig 3 provides the EPC Manager number, identifying the company. This assures that in the rare event a part is sent to the wrong company, it can be identified as belonging to the originating company.

The object class and serial number fields will provide dummy indices with a standard encoding scheme. The middleware will decode the object class field to identify the originating factory and assembly line. The target company is a global company with factories in over fifty locations worldwide. The middleware will decode the serial number field to identify the originating engineer, and the series number of that engineer's tags.

Electronic Product Code			
Header	EPC Manager	Object Class	Serial Number
8 bits	28 bits	24 bits	36 bits
XX	**XXXXXXX**	**XXXYYY**	**XXYYYY**
Tag Type	Specifies company	Specifies Factory and Assembly Line	Specifies Originator and tag sequence

Figure 3 - GID-96 Electronic Product Code

As specified in EPCglobal^{TM} specifications [4], object class numbers are unique within each General Manager Number domain and will be utilized to reference business units. The serial number code is also unique within each object class and will be utilized to reference permanent identification of each individual tag.

Each line will be assigned 500 tags, with series 001-500 specified in the coding scheme, assigned to module assembly line production engineers. This encoding system permanently links a specific set of tags with a module unit so that the tags can be reassigned with each project, and the unit maintains the set regardless of personnel reassignments. This encoding system can be referenced against the manufacturing enterprise system (MES) for a consistent process across the global enterprise system.

Hardware will include an Alien model ALR9900 reader with four Alien ALR 9610-BC circularly polarized antennae at each of the receiving dock doors identified as Station One. [7] A reader and one antenna will be used at the part queue adjacent to the assembly line identified as Station Two, specified as Alien ALR-9650. See Appendix A. The readers will connect via Ethernet to the intranet host computer stations in the receiving area, which will function as edge servers for data capture. The factory IT structure will function as the core server for data intelligence. IT technology architects will adjust existing middleware programs with filters and rules outlined in the next section. It should be noted that the proposed system is applied only to the vehicle assembly lines for a site trial and for ROI calculations, but the application could then be extended to the cab assembly line by equipping the six receiving dock doors in the cab facility. It should also be noted that this system proposal can be coupled with a Kanban tracking application which has already been piloted in one of the factories, which will also improve the ROI. [1]

2.2 System Logic

The data flow relationship in the proposed RFID system is considered an Intra-Enterprise solution. [4] The system will utilize the module manufacturing database as the data source. The tag IDs are permanent and can be reassigned to correlate with new part numbers generated by each product improvement project. A supply of passive Gen 2 WORM tags will be assigned to production engineers on each of the four assembly lines.

The tag GID-96 identity number and series numbers will be entered into the database and correlated with the BOM, as in columns 1, 2 and 3 from the example of Fig 3. As the project proceeds, transactional data is recorded by the reader interface in the form of instance observations. For example, “Station One saw EPC (001) at Time (T),” identifying the station at which the arriving part tag was read, and giving a date and time stamp. The filtering and collection interface, after removing redundant reads, delivers the filtered information to the EPCIS capturing application. For example, “At Station One, between T1 and T2, this group of EPCs was observed,” giving a periodic update of arriving prototype parts. The capturing application “pushes” the EPCIS-level data to the EPCIS query interface, the module manufacturing database. [4] [5] [6] See columns 4 and 5 in the figure, where arrival times are recorded at the receiving dock door and subsequently at the part queue at the assembly line.

GID -96	Tag number	Part number	Station 1 receipt	Station 2 receipt	Zone 2 assembly	Zone 3 assembly
	SK001	AT195447	11/16 11:34	11/16 13:22	01/08 06:55	01/08 13:09
	SK002	AT198534	11/04 07:21	11/04 14:35	01/08 06:55	01/08 13:09
	SK003	AT198756	11/16 11:34	11/16 13:11	01/08 06:55	01/08 13:09
	SK004	AT197209	10/30 10:44	10/30 11:49	01/08 06:55	01/08 13:09
	SK005	AT196670	11/05 15:52	11/06 07:05	01/08 06:55	01/08 13:09

Fig 4 - Manufacturing Database configuration

The capturing application will also generate an email to notify affected personnel that parts have arrived at the receiving dock or the assembly line, however periodic checks of the manufacturing database would serve the same purpose.

The reader at Station Two will have a tighter interrogation zone in order to capture the prototype parts as they pass through the entrance and are placed in the queue. A continuous read of the tags is undesirable for efficiency in data recording so shielding of the storage area may be required. If a part is removed from the queue the reader should read the part passing though the gate and send an alert to the database or the NTA in charge of the queue. The reader at Station Two could be replaced with smart shelves, one shelf for each of the four prototype build vehicles. This application has not been explored in this study.

Although not defined in this project, Figure 1 indicates gates at the end of Zone 2 and Zone 3 on the assembly line. As the prototype parts are assembled to the prototype machine on the assembly line during the build, the tags can be placed in a pouch on the prototype machine as it moves down the line. Readers at midpoint Zone 2, column 6, and final station Zone 3, column 7 of the line would then verify that the complete BOM for that vehicle has been assembled to the vehicle. This is a means to quality check and can be extended according to the needs of the individual assembly line. The tags can be collected at the end of the line and recycled. The progress of the vehicle down the line can also be verified so that all module and design personnel as well as management, some of whom are at remote locations, can check against the schedule of the prototype build.

At the start of production of a new product improvement project, the first several vehicles off the assembly line are typically segregated and passed through a rigorous series of tests to verify functionality of the new design. The process outlined in the preceding paragraph can be repeated at start of production for the first several vehicles that comprise the quality test group. This data collection also provides a record for use in lessons learned.

Another alternative not defined in this project involves replacing the gate reader specified at the part queue with a smart shelf which could and be programmed to display the part number, associated prototype vehicle and assembly station to aid in identifying and sorting the parts for launch. A vehicle mounted reader with audible alert could also aid in locating misplaced parts among the production parts on the assembly line. The prototype part queue is located in an area isolated from the assembly line, so no reads should occur on the assembly line except in close proximity to the prototype queue. If a read occurs on the assembly line, it is an indication that a part has been misplaced among the production parts.

3. METRICS

3.1 Cost Savings in Man-hours

The defining metric for success of this project is a savings in man-hours over the present process and the prevention of a work stoppage. The current manual system requires periodic reviews of the part queue against a printout of the BOM. These are performed weekly early in the program, but bi-weekly and daily as the prototype launch approaches. Periodic deadlines also occur as arrival of long lead-time parts must be verified. In the event that a part is delivered to the assembly line, but is not placed in the prototype queue, a visual search must be done for the missing part. This can take fifteen minutes, or can take an hour or more. The BOM check is generally done by an assembler on a non-traditional assignment (NTA) and is checked by the assembly engineer. The time spent in this routine would be minimized or eliminated. A check of the database gives real-time BOM status.

The most compelling potential benefit is time saved during the prototype build and the avoidance of a work delay or stoppage. The production engineers and assemblers frequently spend time tracking down misplaced parts and identifying specific groups of parts during the prototype build. Streamlining the part location and sorting process can save time and avoid frustration during the build and avert a potential delay.

A simple ROI calculation demonstrates that the installation costs far outweigh the proposed labor savings for a new factory installation:

$$12G + 4Q + 2500T + 10P – 50E – 100N$$

where G = $8000 per dock door gate, Q = $1100 for queue gate, T =$1 per tag, P = $30 per hour for IT programmers, E = $35 per hour for engineers and N = $17.50 per hour for NTA personnel. The project ROI for a factory with gates in place, however, can easily be realized in one product improvement project. If a work stoppage or project delay, which can easily cause lost opportunity costs of $100,000 is taken into consideration, even a new installation is justified.

REFERENCES

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[6] EPCglobal, "The Application Level Events (ALE) Specification, Version 1.0," EPCglobal Ratified Specification Version of September 15, 2005, http://www.epcglobalinc.org/standards/

[7] Alien Technology Product Page, http://www.alientechnology.com/products/index.php

Appendix A

Product Overview for

Specified Components

Appendix B

Document from Reference [1]