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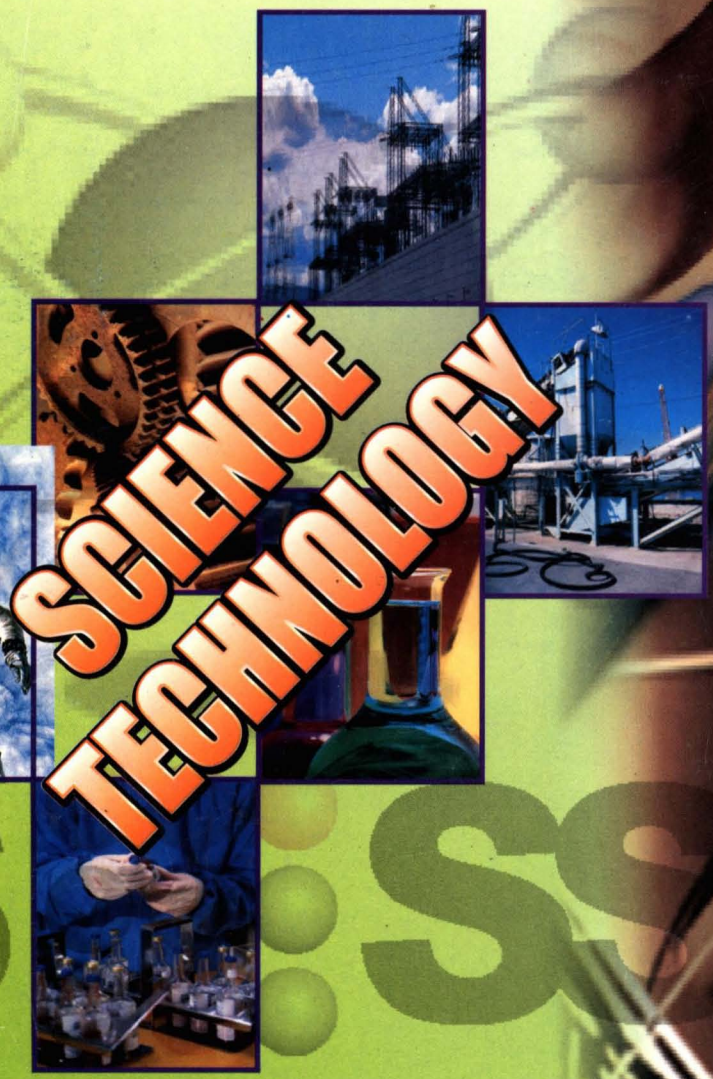

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RFID Technology for Aerospace Supply Chain: Application Perspectives

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ABSTRACT

RFID (Radio Frequency IDentification) is a new technology that is starting to have significant impact on the aerospace supply chain management. It has become an increasingly recognised technology with its strong tracking and tracing ability at a much greater level of accuracy, real-time and providing more value at each step in the supply chain. With the aerospace environments becoming more and more competitive, and their information systems are sharing the fundamental information of assuming rather than knowing where and what things are, RFID technology provides the solution for closing the gap between the physical flow of materials and the information flow in the production system. In this paper, RFID technology is reviewed with respect to various application aspects in the aerospace manufacturing and maintenance industry in the light of enhancing manufacturing intelligence and delivering added-on values. The applications include production planning, operation and quality control, product tracking, maintenance and repair, inventory tracking and visibility as well as labour productivity.

Keywords: *RFID, wireless communication, supply chain, aviation, MRO, aircraft manufacturing*

Introduction

RFID technology is already having a major impact on the aerospace industry with prime aircraft manufacturers such as Boeing and Airbus are now seriously looking into adopting this emerging technology. It has been identified as a fast moving technology with opportunities to gain real business benefits from their use throughout the aerospace supply chain.

Recognising its potential, in November 2003, a research centre, *Cambridge Auto-ID Lab,* based at the University of Cambridge has been formed to develop the use of RFID and other ID technologies in the aerospace sector (Collins 2005). The "Aerospace ID Technologies Programme" is the first in the world to be launched by the Cambridge Auto-ID Lab focusing on research to remove barriers to broad adoption of RFID within the aerospace industry.

The founding members, Boeing and Airbus, are committed to the programme by facilitating the so-called "Boeing-Airbus RFID Forums" with the main discussion centres around the needs of the aerospace industry, with the goal to educate, inform and unite the industry around standard requirements for identifying parts. Apart from aircraft manufacturers, their first and second tier suppliers, operators, owners, Maintenance, Repair and Overhaul (MRO) organisations, and government agencies will benefit the most from this programme. It will also be of immediate interest to any organisation for which the configuration control of life-limited and rotable components in aircraft, the problem of counterfeit part substitution and the potential for more automated production and distribution are amongst the major issues being discussed (http://www.aero-id.org/index.php). Last year alone, Boeing and Airbus had sponsored collaboratively three Global Aviation RFID Forums to educate their worldwide supplier and partner base. Other companies and organisations have also shown interest, including Embraer, BAE Systems, VI Agents, Air Transport Association (ATA), EPC Global, SITA-SC, Westland Helicopter, Diamond Aircraft, Lockheed Martin, Rolls Royce, Pratt and Whitney, GE, Honeywell, GKN, UPS, Virgin Atlantic, Emirates, British Airways, Lufthansa, Korean Airlines, British Airports Authority, UK Ministry of Defense and US Department of Defense.

RFID provides significant benefits for the entire industry. The manufacturers will get more accurate information about their demand for parts. They will be able to reduce their parts inventory and cut the time it takes to manufacture and repair aircraft. Suppliers will also be able to reduce inventory, improve the efficiency of their manufacturing operations and use the technology to verify to Boeing and Airbus that parts they get are genuine, thereby, reducing the amount of unapproved parts that enter the supply chain.

What is RFID?

RFID is an acronym for Radio Frequency IDentification. In its simplest form, the application of a RFID tag to a unit of inventory allows for the tracking of that specific unit of inventory throughout the supply chain. RFID is not a new technology; it has been around for a while in one form or another. During the World War II the British adopted RFID

to distinguish returning British planes from German ones, although the radar was only able to signal returning planes and not the kind of plane it was. Since then, a lot of research works coupled with improvements in technology have been carried out.

The Basics of the Technology Architecture

Generally, an RFID system consists of the following three components:

- a small electronic data carrying device called a transponder, or a tag that is attached to the item to be identified;
- a reader / writer that communicates with the tag by using radio frequency signals; and
- a host system that contains information on the identified item and distributes information to other remote data processing systems.

RFID Tags

Consisting of RF antennas and integrated circuitary, RFID tags provide instant verification that products are what their labels say they are. Tags can then be applied on any objects depending on application, for instance, containers, cartons or individual product units, as well as people, including as emplyees and customers. Depending on the application, normally there are two type of tags – "active" and "passive".

Active tags are RFID tags that have their own independent power source via a battery that is either internal with the tag itself or external that it shares with other resources battery to supply its required voltage. This type of tag allows for greater Read/Write distance capability, typically up to 300 feet, but is larger in physical size and is a little more expensive. Either tags or reader can initiate data communication.

Passive tags, on the other hand, are RFID tags that have no independent power source and get all its power from the transceiver directly when activated. Passive tags are lighter, smaller and cheaper than active tags since they do not have a battery. Nonetheless, they have a shorter data transmission range typically less than 10 feet.

RFID Reader

A reader (or interrogator) consists of an antenna, transceiver and decoder. Either fixed or movable (handheld devices), it decodes information from the tags after which it passes information to data processor.

Host System

A host system contains information of the identified object and distributes the information to other remote data processing systems. The host system is normally a line of business software application, typically an enterprise resource planning system, warehouse management system, in-cab proof of delivery or proof of collection system. In a similar manner to standard barcodes, RFID tags are merely an automated way to provide input data to the host system. So

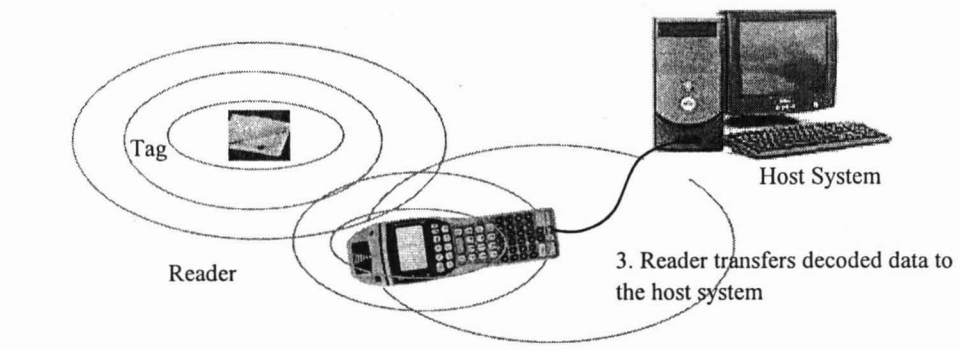

Fig. 1: How an RFID System Works

RFID system is composed of hardware and software, and its work principle can be described in Figure 1.

Limitations of Conventional Manufacturing Systems

There are currently various range and level of automatic identification available in the market. However, manufacturing environments are becoming more and more information-intensive. Barcode is an optical "line of sight" technology where the scanning devices must see the barcode to be read and interpreted. Barcodes may be peel-off, wrinkled or damaged, which make it difficult to obtain a valid scan. While barcode system is widely used to get the information about the parts, it can neither store sufficient information, nor identify a mobile object timely. Furthermore, information cannot be re-written with the change of manufacturing processes. So utilising RFID technology to track parts, equipment etc, while integrating it with MRP, provides real time visibility. See Table 1 for further details.

Table 1 : Comparison between Barcode and RFID

	Barcode	**RFID**
PROS	Low cost Widespread utilization Readable by humans	No line of sight required Can store more data Covert and hard to counterfeit Automated processing Can be read in bulk
CONS	Line of sight required Limited data storage Manual, one-tag-at a-time processing on conditions Easily damaged (dirt, water, scratches)	Higher cost (expected to drop) Lack of standards Passive reading dependent

Manufacturers have pursued practices such as lean manufacturing and Just In Time (JIT) concept to obtain the benefits of reduced inventory in manufacturing systems. However, the best laid plans can be impacted when major disruptions to the supply chain occur. Preparation for such events causes companies to build up a buffer of inventory. For instance, each day Boeing sends 4,650 shipments of spare parts to its airline customers worldwide. The airlines have an estimated 44 billion of unused spare parts on their shelves (Violino 2004). To trim these inventories for both Boeing and airline is the significant benefits while ensuring parts are always where they need to be to keep the aircraft flying.

RFID Application in Aerospace

For potential manufacturing applications, this section will present six typical RFID applications in manufacturing industry, including labour productivity.

Production Planning and Control

A local aircraft parts manufacturer, Asian Composites Manufacturing (ACM), which manufactures the whole range of Boeing's aircraft wing trailing edge and leading edge parts for B737, B777, B747, B757 and B777, is relying on bar code system and "physical identification" to track parts throughout the factory floor. Undoubtedly, the production system needs to have the ability to determine process planning, production rate and corresponding capacity which finally coordinates the flow of material through the factory. In addition, it must specify the levels of support such as material purchases, inventory and human resources needed to support this operation.

As the production system becomes more and more advanced, new system has been introduced, among others is ERP system (Enterprise Resource Planning) to manage the production. However, detailed information on manufacturing process has not been so easily tracked resulting in the ERP has no idea of what is really going on the factory floor. RFID can provide the manufacturing system with the accurate, timely and detailed information it requires to operate effectively. Figure 2 presents a proposal for RFID based manufacturing system of a composites manufacturing process. In this system, tags move with material flow, and readers, connected to information flow, collect data from tags via radio frequency. As such the manufacturing planners are able to know the details of material flow timely, and in accordance to the changes occurred in the supply chain, readjust the production plan dynamically.

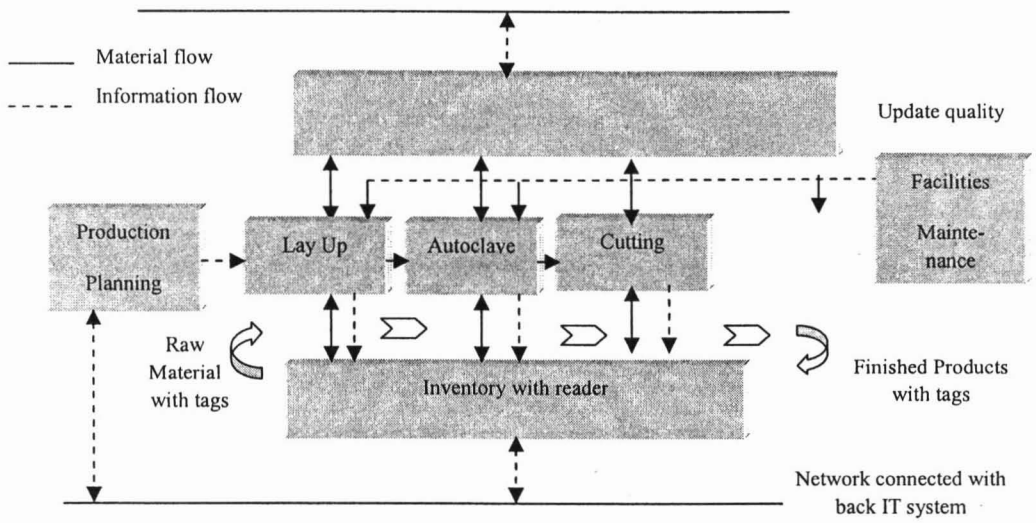

Fig. 2: Architecture for RFID based manufacturing systems

Product Traceability and Recall

Although the amount of product recall in aerospace sector is fairly small, it is not to be taken lightly of the possible risks. With RFID, once a product has been manufactured, the history of product or material can be tracked at a very detailed level in the following areas: where the product or material came from, who did what to it, where it is and where it has been. Batch/lot control track and trace is much easier to perform, as are pinpoint product recalls. So product tagged with RFID transducer can make it possible to trace where it is, which can reduce the cost in recalling, speed up the processing and satisfy customers dramatically.

Inventory Visibility

Pentagon of the U.S. Department of Defense has put a mandate that for all defense suppliers, a Unique Item Identifier (UIIs) will need to be affixed to or directly marked on specified parts or products by Jan 1, 2005. As one of the suppliers to Pentagon, Boeing has intensified research in RFID technologies and has been at the forefront of radio identification tags, which – unlike current bar code labels – and helps Boeing tracks the components/parts better, faster and cheaper by reducing cycle times, defects and costs (Sopranos 2005).

To adopt RFID technology in inventory management, tags should generally be attached on each item or package or container, and readers are placed at door for entrance and exit (Figure 3), or on the ceiling and wall with the distributing in array in order to cover the range of the goods to be traced.

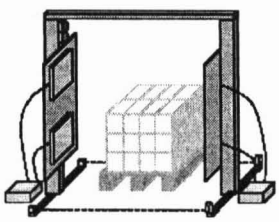

Fig. 3: Inventory visibility

Reader can also be handheld for positioning the item immediately, especially for finding the displaced item which is usually considered as missing item. For the first case, when object passes over the antenna on its way to being loaded onto a truck, the tag ID is compared to a manifest held in a host database. If the ID matches the database information, then the object can be shipped. A "no match" result can make the database also record the time and date.

Maintenance and Repair

Aircraft maintenance cost is undeniable high. Apart from planning inefficiency, hidden maintenance cost such as production losses due to downtime, planning inefficiency are some examples that can incur the cost. So to improve the maintenance process is a big challenge and opportunity for airlines or repair organisation. It is obvious that a good preventive maintenance system can avoid breakdowns as any defects on aircraft can often be fixed in time. Boeing is undertaking their pilot test on RFID based aircraft maintenance. RFID tags will store and transmit information about a part: manufacture date, part number, hours in service, repair and modification history—among other information (Griffin 2005).

With the adoption of RFID technology, aircraft engineers or mechanics can walk through an aircraft parked at an airport while watching the screen on a handheld device. They will receive status reports from key aircraft components, including their maintenance history and required repair schedule. Noticing that a part is nearly ready for replacement, he notifies the repair shop at the aircraft's next destination so engineers there can ensure there is a new part on hand and can install it when the aircraft arrives. This is a future scenario that airline operators such as MAS or Air Asia, for instance, can expect, which make it easier to track and repair parts throughout their life cycle, prevent substandard parts from making it into service and help airlines reduce parts inventories.

In the workshops, there are hundreds of components lying around, some to be repaired, some awaiting to be tested, and there are thousands of document to be certified but without proper tracking system and identification that could cause complication. In addition, workshop technicians need to keep track of these components records, for example, the calculation of overhaul hour, time between overhaul, next repair hours etc. With RFID technology, tags are writable, sometimes active, with special sensor to meet the need of feedback status of object in repair shop (Figure 4).

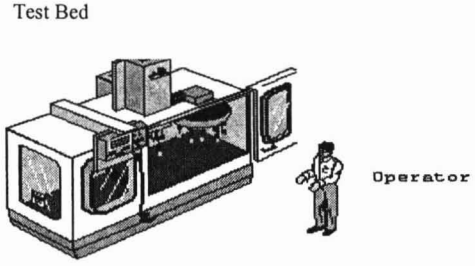

Fig. 4: RFID in Component Overhaul

Quality Control

In aircraft parts manufacturing, quality of products is inspected by the quality inspectors at a number of stations. Any anomalies in the process will be recorded for improvement and future reference. When the product is inspected at the end of the production process, it must be possible to unambiguously attribute the quality data gathered earlier to the correct parts. However, bar code labels are not writable, and can hardly carry these quality information obtained during the production process with the product.

In case of automatic manufacturing lines, the components are tagged with barcode labels, which can be used to trigger the next process. For the same reason, these components can be misplaced or read with some mistakes and, thus, have direct impact on the reliability of the system. Due to hardly tracing and identifying these components accurately, it sometimes will require human intervention which will incur additional production interruption and, therefore, cost.

Labour Productivity

One important area that will meet the attention of manufacturing planners and managers is labour productivity. According to Schnorbach (2004), on average, there are 75 minutes of unproductive time per employee eight hour shift, and the potential for savings is enormous. To manage the labour effectively, one aspect that requires attention is the tracking of individual performances throughout the day. If we could replace the human works involved in manufacturing or maintenance process, such as keying in data, we could have saved a lot of time. Adopting RFID tags to trace workers (by integrating tags in employee ID) is also helpful if the workers are assigned to work in dangerous area such as machining and enclosed areas (fuel tank, autoclave, painting booth etc). If there are some readers in dangerous places, RFID system can distinguish workers from materials by specific ID and give alert when they approach by mistake.

RFID Standard in Aerospace

Aerospace standard is one area to watch because it is international in terms of requirements and subjected to regulatory approval. As of now, it is not as much of issue because Airbus, Boeing and airlines have collaborated with the Air Transport Association's Automated Identification and Data Capture Task Force agreeing to develop commercial aviation RFID requirements, which they deployed in Chapter 9 of ATA Spec 2000's electronic business standard. Boeing has just recently added passive RFID transponders as an option to the bar coding scenario in that document. In addition, the tags Airbus and Boeing are using already comply with ISO 15693 (Tegtmeier 2004).

Future Works

Among key researh areas that will command aircraft manufacturers attention will be likely:

- Testing RFID tags on composites materials
- Promoting development of improved chips capable of storing more data
- Research in ultra-high frequency tags, which can be read from a greater distance
- Lifecycle ID management
- RFID enhanced track and trace
- ID technologies application matching

Conclusion

RFID is an emerging technology that has captured the interest of the aerospace sector. It is the technology that can read data from various distances and has helped improve aeropace manufacturing with more value at each step in the supply chain. It has affected almost everything in the aerospace supply chain, from part tracking to quality inspection to maintenance and repair. Being the bridge of products flow and information flow, RFID will be applied in much wider and deeper manufacturing areas throughout the product lifecycle to increase production efficiency, reduce the cost of supply chain, quickly respond to the change of manufacturing environment and better satisfy customers.

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