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RFID value in aircraft parts supply chains: A case study

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ABSTRACT

The value of Radio Frequency Identification (RFID) in the maintenance of supply chains of aircraft parts is examined, particularly in the proposed analytical model. This model helps us gain a better understanding of the relationships between various costs incurred and the RFID effect on an aircraft maintenance tracking process. Using an RFID system, a maintenance company specializing in aircraft parts can accumulate savings based on the assumption that the technology can eliminate inaccuracy problems related to inventory recording delays brought about by mishandling in the component repair process. This case study illustrates such phenomenon through the use of numerical assumptions, highlighting the benefits of RFID. Further, the value of RFID in aircraft maintenance is evaluated using sensitivity analysis, in accordance with the parameters of the model of cost reductions in mishandling repair components and inventory control. The findings support the industry's acceptance of RFID technology, proving that this is beneficial to maintenance companies of aircraft parts.

1. Introduction

Radio Frequency Identification (RFID) is an interesting area for research because it is a relatively new technology but is already undergoing significant growth (Ngai et al., 2007). RFID has high potential in aircraft maintenance because Airbus and Boeing are already using RFID technology for tagging the parts and components of aircrafts. In fact, Boeing started adopting RFID technology in the late 1990s, when it began using RFID in closed-loop manufacturing automation and asset management applications (O'Connor, 2005).

The approval by the Federal Aviation Administration (FAA), one of the main agencies worldwide responsible for the certification of new aircrafts, on the use of passive ultra-high frequency (UHF) RFID tags on individual aircraft parts for commercial aircrafts opened up a number of RFID-based applications by incorporating RFID tags on high dollar value items, line replaceable units, limited lift parts that need to be frequently inspected, repaired, and replaced, and on-board emergency equipment for airlines. Aircraft maintenance companies and aircraft manufacturers also planned to tag some of their maintenance-significant parts. One of these companies is Boeing, which planned to tag its 787 Dreamliner (O'Connor, 2005). Boeing is most concerned with improving its business processes. The company believes that RFID is a means to that end, but what is really driving Boeing's push for RFID is the increased data, through identification and sensing, that it provides (O'Connor, 2005).

Airline operations in the Asia Pacific region are increasingly realizing the benefits of outsourcing non-core aspects of business such as maintenance operations, especially those on heavy or long-term maintenance. This provides a good opportunity for independent maintenance, repair, and overhaul (MRO) service providers. However, major weaknesses that impact the efficiency of the MRO process are found in inadequate inventory management for parts, human errors, and checking procedures.

RFID technology has high potential in the area of aircraft maintenance. Extensive requirements regarding quality, safety, and documentation, as well as high costs for having aircrafts idle during maintenance, demand efficient execution. The costs of having planes idle during unplanned maintenance are estimated at US$23,000 per hour (Brown, 2003).

The company covered in this study has considered maximizing the efficiency of life cycle asset management by tagging containers of repairable items, parts and components, and the tools that require maintenance. The company, operating two airline maintenance centers [one located at the Hong Kong International Airport at Chek Lap Kok (CLK) and the other at Tseung Kwan O (TKO), a large reclamation area in Hong Kong] has two hangers capable of accommodating wide-bodied aircraft fully docked for

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maintenance. The company believes there is great potential in applying RFID technology to improve asset visibility in the maintenance cycle. This study illustrates how RFID can be used to achieve better visibility and reduce the risk of being severely penalized for failing to replace damaged components because of poor inventory control.

The paper specifically addresses the following questions: (i) What is the value of RFID in aircraft parts maintenance tracking? (ii) What is the impact of item-level RFID on aircraft maintenance? (iii) What value do we gain from RFID initiatives in aircraft parts tracking? (iv) What are the relative benefits of this initiative?

The rest of the paper is organized into topics. Section 2 covers a review of previous studies on the application of RFID technology in industry. Section 3 focuses on the value of visibility in aircraft maintenance made possible through RFID (based on the experiences of an aircraft company in Hong Kong). The section illustrates a real case showing how to evaluate RFID information. Section 4 performs a sensitivity analysis to further evaluate the value of RFID. Section 5 provides concluding notes and possible future directions. The appendix includes proofs of all propositions.

2. Literature review on RFID applications in aircraft maintenance

Academic research in RFID has significantly increased over the last few years (Ngai et al., 2008). RFID has been successfully used in the retail (Fosso Wamba et al., 2008; Thiesse et al., 2008; Bhattacharya et al., 2010), supply chain (Bottani and Rizzi, 2008; Visich et al., 2009; Sari, 2010), and manufacturing industries (Swedberg, 2006, Thiesse and Fleisch, 2008; Liu et al., 2009; Brintrup et al., 2010), and its use is growing rapidly as costs come down and benefits are recognized. RFID is an enabling technology in airports and aircraft, which helps improve security and ensures better baggage handling, safety against general hazards, and tolling without causing congestion. However, there is still limited academic research on RFID applications in aircraft maintenance. Lampe et al. (2004) proposed a solution using ubiquitous computing technologies that improve aircraft maintenance and provide a high level of usability. Chang et al. (2006) presented an RFID-enabled aircraft maintenance system integrated with an inventory control system and an aircraft scheduling system to ensure on-time performance and safety of passenger and cargo. Ellickson (2006) showed that RFID can offer complementary capabilities that can increase the efficiency of helicopter maintenance operations and provide cost savings in the performance of maintenance. Ngai et al. (2007) presented a case study on the research and development of an RFID-based traceability system in an aircraft engineering company in Hong Kong. The system was used to support the tracking and tracing of aircraft repairable items in the company effectively. Ramudhin et al. (2008) introduced a generic framework that can be used in the design of an RFID-based tracking and control system. The framework was applied to the service center of an aircraft engine manufacturer specializing in maintenance, repair, and overhaul (MRO) activities. Two RFID part tracking systems were proposed and piloted. Chang et al. (2011) presented the design and implementation of an RFID-based cargo monitoring system which supported tracking and tracing in air-cargo operations. In order to apply a proper RFID technology, they studied Radio Frequency (RF) operational environment and tested different RFID frequencies. Aircraft maintenance industry practitioners have shown strong interest in RFID because it can help improve quality of services, facilitate information sharing, ensure safety, and realize savings. These advantages make RFID applications extremely useful and interesting. This emerging technology will continue to draw significant attention from the academe and practitioners.

3. Research methodology—case study

Case study methodology is preferred in examining contemporary events (Benbasat et al., 1987; Yin, 1989). This also applies in the current RFID study. Case study is a common approach to information systems/operations management research in the "real world." The strength of the case study approach is that it enables the capture of reality in considerably greater detail than is possible with any of the information systems/operations management research approaches (Galliers, 1992). Therefore, the proposed conceptual model will be illustrated and validated using a case study.

The company in the case study provides comprehensive aircraft base maintenance services that include heavy maintenance, modification, repair, and overhaul of commercial aircraft and their components in the Hong Kong International Airport at Chek Lap Kok. The company provides comprehensive aeronautical engineering services to airlines and airline operators in Hong Kong. It also provides a comprehensive line of heavy aircraft maintenance services, including extensive aircraft component overhaul (COH) support, avionic overhaul (AOH) support, and aircraft on ground (AOG)/aircraft recovery services at the Hong Kong International Airport at Chek Lap Kok. AOG for aviation maintenance indicates that a problem is serious enough to prevent an aircraft from flying. These may require emergency replacements because a grounded aircraft often needs a new aircraft part. The most urgent requirement in an AOG situation is to find the needed part as soon as possible because of the high costs incurred by a grounded aircraft. Every minute on the ground can mean losses in revenue and upset customers.

RFID technology bears a high potential in the area of aircraft maintenance. Extensive requirements regarding quality, safety, and documentation as well as high costs for having aircrafts idle during maintenance demand for an efficient execution. The importance and the need of RFID technology to support aircraft maintenance have been recognized. With more organizations becoming interested in using RFID technology and with RFID systems assuming an important research effort, to date that has not resulted in various conceptual models or scholarly investigations of the RFID implementation process (Curtin et al., 2005). These include reduced shrinkage, reduced material handling, increased data accuracy, faster exception management, improved information sharing, better production tracking, efficient quality control, improved supply and production continuity, reduced material handling, effective space utilization, better asset management, reduced stockouts, improved customer and aftersales service, and lower inventory, among others (Tajima, 2007). Among these benefits, Lee and Özer (2007) have identified three major ones that are quantifiable including labor cost savings, inventory reduction, and shrinkage and out-of-stock reduction. One of the goals of the aircraft maintenance company is to improve visibility. Visibility allows an organization to track a part-repair order as it passes through the supply chain. Traceability, on the other hand, allows firms to trace individual operations, that is, each component has a unique identification number, e.g., electronic product code. Visibility and traceability also aid in reducing costs associated with maintenance and repair. Visibility allows service personnel to track orders from the point of origin to the final destination and thus more accurately schedule aircraft and personnel. This reduces downtime and ensures that appropriate personnel will be available. Traceability ensures that the specific parts dismantled for repair have been handled properly and sent back without delay to the designated facilities for future reuse. It also helps ensure that components to be repaired are correctly retrieved and installed back to the planes. The buyer can verify if the specific part was delivered if

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