AN ANALYSIS OF THE POTENTIAL APPLICATION OF RFID TO HELICOPTER MAINTENANCE OPERATIONS

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Sean Ellickson

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APPROVAL

Name: **Sean Ellickson**

Degree: **Master of Business Administration**

Title of Project: **An Analysis of the Potential Application of RFID to Helicopter Maintenance Operations**

Supervisory Committee:

____

Dr. Aidan Vining
CMABS Professor of Business and Government Relations
Faculty of Business Administration
Simon Fraser University

____

Dr. Michael J. Brydon
Assistant Professor
Faculty of Business Administration
Simon Fraser University

Date Approved: December 4, 2006

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ABSTRACT

The analysis seeks to determine whether adoption of Radio Frequency Identification (RFID) provides strategic benefits to global helicopter service firms that rely on the continued safe operation of high value, maintenance-intensive equipment. The first chapter of the analysis examines RFID technology, including industry and market factors related to adoption. Subsequent chapters present a helicopter industry analysis, an assessment of the current situation facing industry participants, and the strategic alternatives for a typical helicopter firm. The strategic alternative that includes the adoption of RFID is preferred as it increases operational efficiency and enhances competitive factors. While RFID typically identifies and tracks products in the supply chain, the technology offers complementary capabilities that can increase the efficiency of maintenance operations. As a result, this analysis determines that RFID increases competitiveness by integrating value chain activities, reducing cost and improving performance of maintenance operations.

EXECUTIVE SUMMARY

This analysis seeks to determine whether Radio Frequency Identification (RFID) can increase service quality or decrease costs associated with helicopter maintenance operations, and how such a technology investment would impact a firm's competitive strategy.

RFID technology has seen rapid adoption in supply chain applications. The technology provides increasingly granular information on products and allows suppliers to respond more quickly to changing inventory or market data. Recent technological advancements are expanding the capabilities of RFID and the potential application in helicopter maintenance operations provides valuable benefits to a helicopter firm.

An analysis of the helicopter industry determines that there is high rivalry between competitors, high supplier bargaining power, and considerable scale effects and learning curves. As a result of these and other factors, the industry is not attractive to enter. The four large helicopter operators examined differ in their competitive approach and diversification, but all compete in a market where the key success factors are cost, aircraft reliability and customer service. These success factors compel competitors to compete based on a differentiated strategy, but with a significant focus on cost.

A typical firm creates value primarily through three interrelated value chain activities: helicopter operations, logistics, and repair and overhaul. Logistic effectiveness supports the successful delivery of these activities, and all have a direct effect on cost, safety and reliability. Helicopter maintenance operations is a complicated task that relies on the effective determination and provision of maintenance resources to ensure aircraft continue to operate safely and efficiently. Strategic alternatives must support industry

key success factors but this can lead to decreased differentiation among competitors as no firm chooses to move too far toward either cost-based or differentiated strategies.

The application of RFID to asset tracking, supply chain and maintenance operations integrates the primary value chain activities, improves their effectiveness and efficiency, and addresses the key success factors of cost, reliability and customer service. This technology impacts cost and differentiation drivers and allows a firm to accomplish value chain activities more efficiently than its competitors; in fact, the technology impacts 85% of a typical firm's value creating activities and provides interrelationships between activities where none existed before. Integrating the effectiveness between these activities enhances the competitive effect.

This analysis determines that the adoption of RFID technology and its application to maintenance operations in the helicopter industry provides qualitative and quantitative benefits. The benefits include faster response to issues, greater productivity, reduced cost and enhanced aircraft serviceability, which result in additional sources of differentiation and increased competitiveness. This innovation has the ability to reduce cost, increase efficiency and enhance activities throughout a firm's value chain. It also presents a competitive advantage in an industry that lacks such differentiators, particularly as a result of technological innovation.

DEDICATION

This MBA program would not have been possible with the kind support of my family. I am so grateful to all my family including my mother and father, and my brother-in-law, Michael, who generously created a graphic for this project. My greatest gratitude is to my wife, Marcia, who has inspired and supported me throughout this journey while she endured years of missed evenings and weekends. For you I am truly blessed.

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1 INTRODUCTION

1.1 Purpose of the Analysis

This analysis seeks to determine whether Radio Frequency Identification (RFID) technology could be effective beyond its current supply chain applications. This document determines whether RFID can increase service quality or decrease costs associated with helicopter maintenance operations, and how such a technology investment would impact a firm's competitive strategy. Helicopter maintenance operations is an example of a challenging and complex environment in which the capabilities and benefits of RFID technology can be thoroughly assessed.

1.2 Introduction to the Analysis

The technology of RFID has been around for decades, although only recently has the technology seen rapid adoption in supply chain management applications. RFID is redefining how businesses in a supply chain interact as it can track a product from manufacture to distribution and eventual customer purchase. The technology provides increasingly granular information on products and allows suppliers to respond more quickly to changing inventory or market data. However, not everyone embraces the technology and consumer groups fear that it will track the product (and therefore the purchaser) long after they leave the supply chain.

Advocates and adopters know the benefit in supply chain logistics but the future applications of the technology are only beginning to emerge. Recent advancements such as increased memory, networking and sensor capability mean that RFID is much more than a "fancy barcode". These new technology developments create new markets whose size may eventually overshadow the original supply chain application.

Businesses are looking for new answers to old productivity problems and RFID may provide the solution. Businesses involved in operating and maintaining equipment know the challenges in providing safe reliable services to their customers. Replacement parts, technical information, and service equipment and supplies are required to maintain operating equipment; and these logistic challenges increase when the equipment is operated in remote locations. Furthermore, when equipment is expensive, maintenance-intensive, and relied upon by the customer, a company faces increased pressure to ensure that the product continues to operate in a safe and efficient manner.

Businesses need to manage the logistics of maintenance and operational activities, known here as "maintenance operations", and ensure these are effective and contribute to their competitive strategy. RFID provides a solution to supply chain visibility and this document examines whether it can move beyond that application to find a new market in maintenance operations. The subject industry is the provision of helicopter services to a global customer base (the "helicopter industry" or the "industry"). The helicopter industry presents a challenging environment in which to assess the suitability of RFID in maintenance operations. Helicopters typify cost and maintenance-intensive equipment. Their continued serviceability is critical for customers whose operations cease without this necessary transportation or support. Helicopter operators realise the impact their unserviceable equipment has on the customer and are well aware of the non-performance penalties levied against them.

Helicopters also rely on large amounts of information. The exchange of technical, regulatory, maintenance and operational information between remote job sites and a firm's headquarter is constant. Furthermore, the cost of spare parts and tools dictates that a full complement cannot possibly reside with each aircraft. As such, effective communication of needs from the field and dispatch of products to the field are integral to ensure rare and expensive support assets are best utilised.

This analysis takes a generalist approach to asses the impact of the technology on the helicopter industry and, as such, the potential solution could apply to any competitor within this industry. This analysis also provides insight into the maintenance operations market segment for those within the RFID industry.

1.3 Structure of the Analysis and Document

Chapter one introduces the analysis and describes its purpose and scope. It also introduces RFID technology and the concept of maintenance operations. Chapter two examines numerous aspects of RFID technology. It presents an overview of the technology and its components before providing a look at current and future RFID applications and benefits. The chapter also presents factors that are impacting the technology, its industry and society in general.

Chapter three focuses on analysing the global helicopter industry by employing recognised analysis methodology. It presents four major competitors and discusses industry activities and forces that shape competition.

Chapter four assesses the industry analysis and presents a strategy for increasing a firm's competitiveness by applying RFID technology to value chain activities. Chapter five examines the strategic alternatives available to competitors to determine the most effective approach. Chapter six then examines the application of RFID technology in maintenance operations and determines the technology's ability to address helicopter industry competitive factors. It also presents an implementation strategy and a brief analysis of cost and benefit.

Finally, chapter seven summarises the key issues presented within the analysis and proposes strategic recommendations for industry competitors regarding the implementation of RFID technology.

2 RFID TECHNOLOGY REVIEW

2.1 Purpose of the Chapter

This chapter presents a summary of RFID technology and its applications. It discusses the history of the technology and provides an overview of the components involved in RFID systems as well as other factors affecting RFID technology and industry trends.

2.2 Introduction to Automatic Identification and RFID

Automatic identification technology, or Auto-ID, has been with us for decades. Every day supermarket checkouts read product barcodes and integrate this barcode data into their configured database to provide product price and update inventory levels. This “classic” Auto-ID technology is, in fact, relatively new. Barcodes are one of the most recent additions to Auto-ID technology, as the now ubiquitous Universal Product Code, or UPC symbol, that is attached to most products was not introduced until 1972 (Garfinkel and Rosenberg, 2006).

Radio frequency identification, or RFID, is an Auto-ID technology that uses a radio frequency signal to communicate the data held and maintained on an RFID chip. Although often considered a new technology, early RFID technology was in use long before the barcode. The first use was in the Second World War when allied aircraft responded to British radio frequency queries that requested them to “Identify as Friend or Foe”, and this “IFF” technology is still prevalent in aircraft today. Instead of being an optical technology like the barcode, the radio frequency used in RFID allows for greater range and is not limited to line-of-sight like optical Auto-ID technologies.

Early radio frequency (RF) technology in garage door openers and remote controls pre-dated the more modern RFID, which now controls books in libraries and has done so since the 1970s. Over the past several decades, advances in integrated circuit and other technologies have allowed RFID to find its way into an incredible number of diverse applications. These vary from automated highway toll systems, personnel access and inventory control, supply chain management, passport authentication, to implantable animal and human tracking (RFID Exchange).

RFID use has been steadily growing but its most widespread adoption has been the result of powerful organisations such as Wal-Mart and the U.S. Department of Defence (DoD) that employ the technology in supply chain management. The DoD uses RFID technology to identify shipping containers and the products within them to ensure appropriate materiel control within the theatre of war. The DoD learned hard logistic lessons during the 1991 Gulf War and the DoD subsequently mandated its 30,000 suppliers to adopt RFID technology in 2003 (Bhuptani & Mordapour, 2005).

As the world's largest company, Wal-Mart mandated its top 100 suppliers to adopt the technology no later than 2004. The cost to the consumer goods suppliers was significant and estimates placed the cost between $13 and $23 million for each early adopter. Wal-Mart was committed to increasing goods availability from 99% to 100% of the time. With Wal-Mart's size, this efficiency represents an extra $1 billion in sales revenue (Shepard, 2005).

These two organisations affect thousands of suppliers and the rush to meet the requirements has accelerated growth in the industry and the technology. The mandates from both the world's largest military and consumer goods company have been the catalyst for rapid adoption and technology development. By 2006, Wal-Mart's phased approach will have more than 25,000 suppliers using RFID, while the DoD will have 43,000. Of course other companies are adopting RFID so as not to lose competitive advantage through increased productivity or capabilities.

2.3 RFID Technology

The information held on an RFID chip is an Electronic Product Code, or EPC. While the UPC information of a barcode provides manufacturer and product information, the information provided by an EPC is vastly more comprehensive. When scanning an EPC at a checkout, the tag communicates to the inventory management system when and where the scanning took place; and not only does it identify that it was a particular type of product, it also identifies the individual occurrence of that product type. With an EPC, every product has a unique serial number and it is possible to track millions of trillions of distinct items (Sweeney, 2005).

RFID has several key features that differentiate it from other identification technologies, and these ultimately influence the technology's adoption. Typical RFID tags are: unique- every tag can contain a unique serial number (an EPC); invisible- tags need not be visible or in line of sight to be read; programmable- tags can be written to initially and some can be updated as products complete process steps (quality inspections, location changes, etc.); robust- tags can be housed in tough plastic materials that can protect them from harsh environments, and; capable of reading multiple tags simultaneously- even when the tags are moving quickly or at a relatively large distance from the reader.

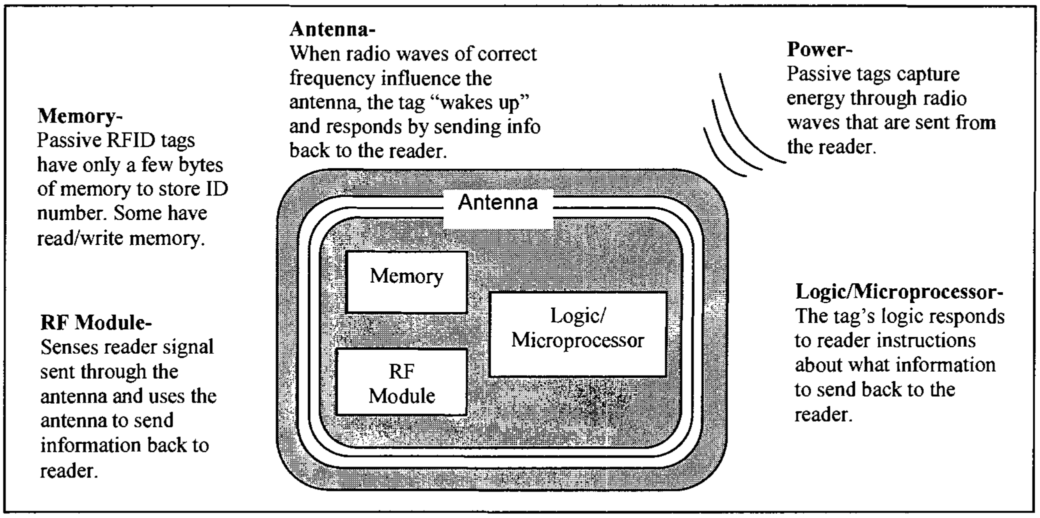
2.4 Components of an RFID System

An RFID system is composed of only a few separate components: a tag; an RFID tag reader; an antenna; and a host computer that is equipped with the necessary software.

2.4.1 Tags/Transponders

The tag, also known as a transponder, is the basis of the RFID system and every product or shipment is equipped with an individually-identifiable tag. Every tag has an antenna and a silicon ship that includes memory, a radio frequency receiver and transmitter, and power and logic systems. All tags require energy to operate. There are two types of tags defined by the source of their energy: passive and active. Passive tags acquire energy from the incoming radio frequency waves, while active tags use power from a battery or an external energy source. Figure 2.1, below, shows the basic structure of a passive RFID tag.

Figure 2.1: Basic Passive RFID Tag Structure



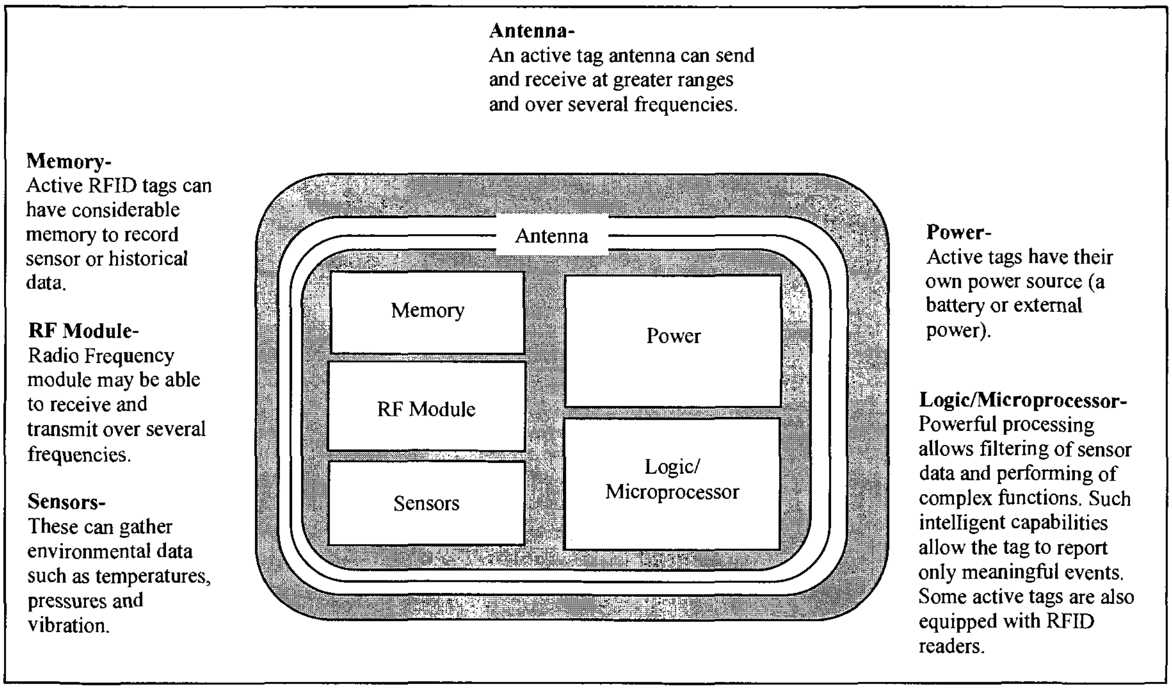
Source: Adapted from Heinrich, 2005 p.72

Passive tags have many advantages over active tags. They are typically smaller, cheaper and last almost indefinitely, as there is no battery to wear out. Passive tags can operate on incredibly low power levels (micro- to milli-watts); however, they have short transmission ranges and do not perform well in electromagnetically-noisy environments. Passive tags can take almost any form and are commonly available as adhesive tags or moulded into car keys. The smallest RFID tag, the Hitachi mu-chip at less than 0.4 mm thick, can track individual sheets of paper (Garfinkel & Rosenberg, 2006). More frequently, passive tags are about the size of a grain of rice which allows for injection under the skin of animals or humans. However, the most common passive tag is the flat adhesive label found on consumer products. Generally, the larger the tag, the farther it can be read (Thornton *et al*, 2006).

RFID tags can contain data that represents their identity or they can simply be on/off, which is common in electronic article surveillance used to prevent shoplifting. In these applications, the RFID transponders simply identify their existence but do not hold any data about the product's identity. Tags used to track packages, pallets or personnel are more complex. These are required to have a sufficient number of bits to retain information on the person or product. This data may include date of manufacture, price or security authorisation.

Active tags are larger because they contain a battery. The batteries have a very high power-to-weight ratio and can operate in temperatures of -50 C to +70 C for up to 10 years. While active tags may not have the simplicity or low cost of passive tags, they have considerably more features and advantages; notably, read range and reliability. Some active tags allow for a read range of over one hundred feet as they are not dependent upon consistent RF energy for power. Also, because of their own power source, active tags provide greater read reliability. In general, active tags offer greater data transmission rates and ranges, and offer better noise immunity. Figure 2.2, below, illustrates the basic design of an active RFID tag.

Figure 2.2: Basic Active RFID Tag Structure



Source: Adapted from Heinrich, 2005 p.72

2.4.2 Readers

Readers, sometimes known as interrogators, send out pulses of RF energy to wake dormant tags within the reader's range. The reader then listens for the response of the tag's serial number and, if applicable, other tag information. When a tag enters a reader's field, the tag and reader exchange information in a process known as coupling. Readers may act as simple on-off switches for tags or they may communicate more complex read or write instructions. Readers vary in size depending on their application. They can be large powerful panels used for long range reading purposes or as small as a few centimetres for incorporation into a cellular phone or similar mobile device.

2.4.3 Antennae

The size of the antenna on the reader and tag determines the efficiency of the interaction. A larger antenna on the reader allows for more efficient transmission and reception of RF energy. A larger antenna on a tag means that more RF energy is available to power the chip and more power is available for transmission back to the reader. In many applications, readers incorporate their own antenna.

Antenna systems are usually half the wavelength of the operation frequency, which means the lower the frequency, the larger the antenna required. This varies from 150 cm at 100 MHz to 2.5 cm at 5.8 GHz (Dubendorf, 2003). This attribute has obvious practical impacts on the size of antenna required, and can preclude the use of some frequencies in select applications.

2.4.4 Host computer/network

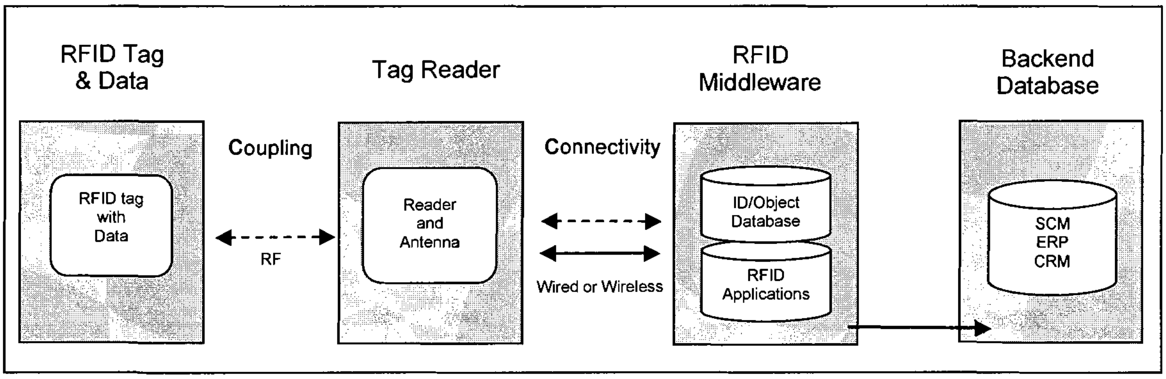
The reader forwards data collected from the tag to a computer system or network that documents and stores the information. In the case of access control, a company's internal computer queries its database to determine if access is authorised for that device (and the person attached to it). In the case of supply chain management, the process is more complex and involves the Internet. The communication of real-time product data between members in the supply chain requires an Internet-based database that captures EPC product data from RFID systems of supply chain members. To allow this, look-up services were needed that could house manufacturing and logistic data. EPCGlobal has adopted an Object Naming Service (ONS) based upon the successful architecture of the Internet Domain Name System (DNS) that maps Internet domain names to Internet Protocol (IP) addresses. This system is so much like the Internet structure that VeriSign, the company that runs the global DNS, won the contract for the global ONS in 2004 (Garfinkel and Rosenberg, 2006).

2.4.5 Middleware

Middleware is the term for software that links two or more software systems so that they can communicate as required. In RFID systems, middleware applies formatting, filtering and logic to tag data so that other software programs can process the data (Burnell, 2006). Typically, the other software program is a company's enterprise resource planning ("ERP") system. Enterprise systems can be any standard commercial database (SQL, Oracle, etc.) and can vary in complexity from one PC to numerous mainframes linked globally over the Internet (Thornton *et al*, 2006).

Figure 2.3, below, presents typical data flow from the tag to the backend sever, which facilitates supply chain management (SCM), enterprise resource planning (ERP) and customer relationship management (CRM). Middleware provides the link between data provided from the reader to the backend server.

Figure 2.3: Data Flow in a Typical RFID System



Source: Adapted from Fine, Klym, Tavshikar, and Trossen, 2006

2.5 Other Aspects of RFID Systems

2.5.1 Frequency and range

One of the most important aspects to effective RFID coupling is the frequency of the radio energy used. The carrier frequencies used are low, high or ultrahigh frequencies. Tag frequency affects the ability of the tag to communicate, as radio wave characteristics vary depending on their frequency. For example, AM radio operates at a low frequency and can cover significantly longer ranges (up to 1000 miles) than the higher FM frequencies, which may only cover 50 miles. Lower frequencies travel farther and can penetrate solid substances better than higher frequency signals, and this provides obvious advantages for some applications. However, while lower frequency signals can power a passive RFID tag up to 1 metre, they cannot carry as much information per second as higher frequency devices. Generally, the higher the frequency, the higher the data transfer and the smaller the antenna (Heinrich, 2005).

Most RFID tags operate in the high-frequency (HF) 13.56 MHz range, which is 13.5 million cycles per second. HF tags can quickly perform complex software actions without the need to slow the product's movement within a facility. Ultrahigh frequency (UHF) tags operate at 868 MHz in Europe and 915 MHz in North America. These offer greater ranges (up to 3 metres on passive tags and 15 on active, internally powered tags). Toll collection applications are the most common use of UHF tags but are not as good at penetrating materials as the 13.56 MHz tags. Microwave tags operate at 2.4 GHz and offer the greatest data transmission and processing speed. Because of the power requirements of microwave tags they are usually active tags. These tags have a greater range (up to 15 metres) and operate without loss of accuracy at speeds up to 400 kilometres per hour (Heinrich, 2005).

The trend is toward smarter tags that provide greater functionality, greater computational power and transmit rates, and these require higher frequencies to power them. The speed of the tag is dependent upon the frequency of the RF emitted from the reader. Table 2.1, below, presents the application and characteristics of common RFID frequencies.

Table 2.1: RFID Frequencies, Characteristics and Applications

Frequency Band	Read Range	Characteristics	RFID Protocols	Typical Applications
LF 100-500 kHz	< 4-6 in	Short-medium read range Inexpensive Low reading speed Works best around metals and liquids Widely deployed since 1980s	ISO/IEC 18000-2	Access control Animal identification Inventory control Car immobiliser
HF 10-15 MHz 13.56 MHz	< 8 ft	Common world-wide standard. Short-medium read range Potentially inexpensive Medium reading speed Can read through liquids	ISO/IEC 18000-3 EPC HF Class 1 ISO/IEC 15693 ISO 14443 (A/B)	Supply chain Access control Smart cards Item tracking Electronic surveillance
UHF 433 MHz 860-930 MHz	10-20 ft	Long read range High reading speed Problems with liquids and metals	18000-6 EPC Class 0,1 18000-6C EPC Generation 2	Railcar monitoring Toll collection systems Supply chain Item tracking
Microwave 2.45 GHz 5.8 GHz	< 3 ft	Moderate read range Line of sight required Expensive Very high data rates Read problems near liquids and metals	ISO/IEC 18000-4	Airline baggage tracking Railcar monitoring Toll collection systems

Source: Adapted from Shorey, 2006; Bhuptani and Mordapour, 2005

2.5.2 Security

Even though RFID is a sophisticated technology used in commerce, its security features raise questions. A group of students hacked into ExxonMobil's RFID Speedpass system, and other students have created malicious RFID worms and viruses. The students inserted the malware within the chip's memory, which passed into the backend database through the reader. However, some RFID tags have advanced computational abilities and can perform decryption and encryption functions. This capability makes it more difficult to modify data on the tag. Regardless, RFID is radio-based and there is little chance of preventing unwanted listeners (Thornton *et al*, 2006).

Security attacks take many forms. Some may want to steal or misrepresent an item by disabling or altering the data on a tag; or the intent may be much more sinister, and aim to disable or infect middleware or the backend database. Tag alteration, known as RF manipulation, is achieved by preventing the reader from reading the tag and this can be as simple as placing the tag in aluminum foil or a Mylar bag. More complex RF manipulation can involve broadcasting incorrect EPC data or changing the data to reflect a considerably lower price (Thornton *et al*, 2006).

The risk of a security attack is low in maintenance operations applications because only identification and maintenance data is available and exchanged. Even though there is no commercial transaction, incorporation of encryption capabilities is likely to decrease unwanted tampering with stored data. This provides increased flight safety as unauthorised agencies cannot update maintenance records of parts.

2.5.3 RFID data storage

Simple EPC identification tags are known as WORM tags, for Write Once Read Many. However, data storage and in-service updating of tag data presents increased application opportunities. In fact, certain RFID applications are dependent upon the ability to extract great amounts of information from tags. RFID tag memory can vary from a few bytes to several megabytes and rapid development is constantly advancing the upper limit. A 32,000 byte tag can hold up to 11 pages of double-spaced text (Heinrich, 2005).

All RFID tags have circuitry that controls the movement of data within the tag. Sophisticated tags can divide the total memory cache and allow readers with the proper password to update sections within the tag. This has obvious applications when numerous parties are involved in the product's production, supply chain or maintenance. Regardless of whether a tag is complex or simple, the tag's logic is either "state machine" or a "programmable microprocessor". The state machine logic is most common and specifies that the tag perform some logical instruction or algorithm. It is effective in encrypting data, controlling tag access through passwords, and performing the complex handshake function necessary to prevent interference between tags when readers scan numerous tags simultaneously. The advantages of this tag include its simplicity, low power use and subsequent low cost. However, it has the disadvantage of being hard-wired at manufacture, which prevents its logic from being changed.

The programmable microprocessor can modify its function through software changes much like a computer. Microprocessor RFID tags can perform more sophisticated tasks such as monitoring data from external sensors. These tags can even have their software and data modified remotely. Such a capability is valuable and essential for tracking production or maintenance activities. Obviously, these tags do consume more power than the less-complex state machine devices (Heinrich, 2005).

2.5.4 RFID sensors and networks

As RFID matures from a passive, short-range identification device, an obvious technological and market extension includes sensor functions. These sensors will be networked and create what are known as wireless networked sensors or sensor nets. Although RFID-based sensing is nascent, its potential applications present a tremendous market opportunity for equipment monitoring in many industries, including heavy industrial, aviation, rail and automotive. In aviation, there currently are wired networks of sensors providing condition monitoring but the requirement to connect the sensors with wire creates a complex and heavy installation. The development of light-weight wireless sensors presents an attractive and exciting opportunity for helicopters, as reductions in weight increase aircraft performance.

RFID-based sensor applications are rapidly growing in capabilities and numbers. These sensors can detect temperatures, pressures, radioactivity, pH, vibration, acceleration and humidity. Tire pressure monitoring systems are an example of an RFID sensor application. This system employs a small chip attached to the tire stem, which sends a signal to the vehicle's warning system when pressure drops below a predetermined level (Poirier & McCollum, 2006). While sensor networks present an exciting future for RFID, the technology has some current hurdles to overcome. RFID-based sensors are expensive and consume 10 to 1000 times more energy than passive tags. As a result, sensor applications only use active tags (Lewis, 2004).

The sensor market will grow from about $100 million in 2005 to $1 billion in 2009; due in part to the considerable research activities of Intel, Motorola, Siemens, General Electric and Boeing. IBM has created a new division to research wireless sensor networks and believes the global market value will be $6 billion in 2007 (Ricadela, 2005). According to Paul Saffo, Director for the Institute of the Future in Menlo Park California, "the impact of sensors will be as surprising in the decade ahead as microprocessors were in 1980s and lasers in the 1990s" (Nilsson).

2.5.5 Alternatives to RFID networks

RFID is not the only wireless technology that can provide short range, low frequency, low transfer-rate wireless networks. Wi-Fi, Zigbee and Bluetooth are newer, short-range wireless technologies that have enjoyed considerable development recently. However, rather than competing with RFID, the common radio frequency innovation accelerates RFID development (Fine *et al*, 2006).

Wireless networks of the future will likely incorporate numerous wireless technologies. The creation and development of RFID readers in cell phones illustrates the potential convergence of RFID with other networking technologies. Radio propagation factors and economics dictate more than one wireless network technology is required to communicate both in distances of a few feet and a few kilometres. As such, varying technologies with different power outputs and frequencies are necessary to achieve coverage across these ranges of distance. Existing RFID, Bluetooth and cellular phone technology, such as GSM, demonstrate the union of disparate technologies that can provide long-range sensor capabilities.

2.5.6 Current and future RFID applications

There are numerous current applications of RFID technology and the rate of application appears to be increasing. Manufacturing, supply chain, retail and security are common applications but as the technology develops, more diverse uses result. These complementary applications create a self-reinforcing effect known as increasing returns to scale (Hill, 1997). As the size of the installed base increases so does the availability of complementary products, which, in turn, increases the attractiveness of the technology for adopters and users.

The most typical application of RFID has been in the supply chain where the technology provides a cost-effective means of gathering additional information on product movements. More detailed information allows supply chain partners to respond more quickly to changing market conditions. Furthermore, the technology provides this information while decreasing the need for human interaction. One of the longest running and most successful applications has been the use of RFID cards or fobs to control building access. Libraries have also used RFID to control book theft and automate withdrawal and return logistics for decades. This technology is not new but its capabilities and its recent reduction in cost have opened up many new markets.

Toll roads are a very large market for RFID. This system allows vehicles with RFID toll-passes to bypass the tollbooth. The system identifies the vehicle and instantly debits the account even when the vehicle whisks by at highway speeds. This application decreases the inconvenience to the road user, provides the road operator with the toll revenue they require, and decreases the need for toll personnel and cash handling logistics. However, as there are no standards, there are many different companies providing toll systems (transponders and readers) and, at this point, a unified national (or international) toll system is not possible (Dubendorf, 2003).

One of the most successful applications and thorough adoptions of RFID technology has been on railcars. Millions of rail cars have been equipped with RFID, which allows the identification of the cars and contents through readers placed beside the tracks, and the system also allows the identification and sorting of cars as they are reassembled in marshalling yards (Dubendorf, 2003).

Sensor-enabled RFID is one of the most exciting emerging technologies. Cost-effective RFID devices can now measure the temperature of meat or other perishable products as they move through the supply chain. It is also possible to record all movements of these products and whether they are subject to deleterious environmental conditions such as shock, temperature or humidity.

RFID also has the potential to support product authenticity which could decease counterfeiting of products and the costs associated with monitoring, warranty, refund and lost sales. Since RFID can track products through the supply chain and provide detailed electronic history of product shipments, its application will raise the cost and complexity of making counterfeit products and will thereby decrease the number of counterfeit products entering the supply chain (Collins, 2004). Counterfeit control is also a concern for the U.S. government, which approved the use of RFID in U.S. passports to provide additional biometric information and security control (Garfinkel & Rosenberg, 2006).

The industry, capability and application of RFID are growing rapidly due to greater memory capacity, processing speeds and reading ranges. The technology is not as cost effective to create as barcodes; however, in applications where line of sight is not practical or where data is required without linking to a remote database, RFID proves a viable alternative that is becoming more cost effective and capable.

2.5.7 Business benefits

RFID is a great advantage to supply chain management because it provides enhanced visibility of products and streamlining of processes. Distribution inefficiencies create as much as $250 billion in waste each year, and a study by Auto-ID claims that RFID-enabled goods management can save $70 billion by reducing carrying costs, labour and shrinkage. Proctor and Gamble estimates that stockouts cost retailers up to 11% of revenues and 85% of shrinkage occurs in transit. Further, one retailer shuts down hundreds of outlets each year to perform a manual inventory. This has an estimated cost of $30-$60 million in salaries and lost revenue (Thornton *et al*, 2006).

RFID has the ability to incorporate passive objects into information technology (IT) infrastructure. This permits intelligent decision making and thereby creates efficiencies, increases process and quality control, and reduces costs. RFID promises better processes due to: the tag's ability to store, modify and upgrade data as parts move through process stages in either manufacturing, quality or logistic phases; accuracy and automation of data collection so that labour and errors are minimised; and, fast and simultaneous reading of multiple tagged items within the read area. RFID technology provides a return on investment from the reduction in labour, theft and inventory, and an increase in productivity and process improvements throughout the supply chain. These benefits are likely to increase through process improvements and upgrades to middleware capabilities (Shorey, 2006).

There is the opinion that RFID is one of the most over-hyped technologies today and will not necessarily result in productivity or efficiency savings. Some believe that the benefits of RFID in the supply chain accrue to Wal-Mart, not the supplier. This may be true as there is a large group of suppliers meeting Wal-Mart's requirements through "slap and ship". This simply means slapping on an RFID tag and shipping it to Wal-Mart without concern for the logistic value offered to the supplier. Conversely, the supplier need not invest heavily in RFID infrastructure including the IT required to handle the huge amount of data. The "slap and ship" approach then equates to a "wait and see" approach, which allows the supplier to defer further investments while technology changes and costs decrease (Poirier & McCollum, 2006).

Furthermore, companies considering implementing RFID have much to consider in regards to standards and systems. While mandated adoption has been a boon for RFID-related organisations, it is expected that as long as five years may be required to gain a satisfactory unifying effort between hardware and software suppliers, development and consulting companies, and industry user groups (Poirier & McCollum, 2006). One of the greatest challenges to RFID success is in the integration of RFID data into a firm's existing IT infrastructure and the alteration of business processes to exploit the benefits that an RFID system provides. The information created is immense and it has to be determined where the information is collected, how much is retained, and for how long. RFID alone will not improve a company's performance without the application of the information and the modification of processes to exploit the technology and the information.

2.6 RFID Industry

Prior to investing in a technology it is prudent to understand both the technology and the competitive forces affecting the technology's industry. Changes in industry competitiveness have an effect upon industry participants and customers, and a potential adopter should understand how future changes might impact them and the technology. The shape of the RFID industry is changing rapidly due to increased adoption, consolidation, standards and growth. The RFID industry is the aggregation of many sub-industries such as hardware, software and service industries. These sub-industries are also collections of more discrete technologies and products. The value of the RFID industry will expand dramatically from $1.5 billion in 2005 to $27 billion by 2015 (Industry Week, 2005).

2.6.1 Middleware

There are several RFID middleware segments: customised middleware, and data and device monitoring and management middleware. Customised middleware was the largest segment and will experience large growth in the next five years. This segment was worth $12 million in 2005 and will be worth $138 million by 2010. The next largest middleware market is data monitoring and management at almost $10 million and this should grow almost $50 million by 2010. The third largest market is device monitoring and management, and this will double in size to $6 million by 2010. Consolidation will continue in the middleware segment and there will be increased reliance on data standards. There are two primary pure-play middleware providers (OAT Systems and Globe Ranger) and these are facing big competition from other software companies involved in database management; namely, SAP, Oracle, Microsoft, IBM, and Sun Microsystems (O'Connor, October 11, 2006).

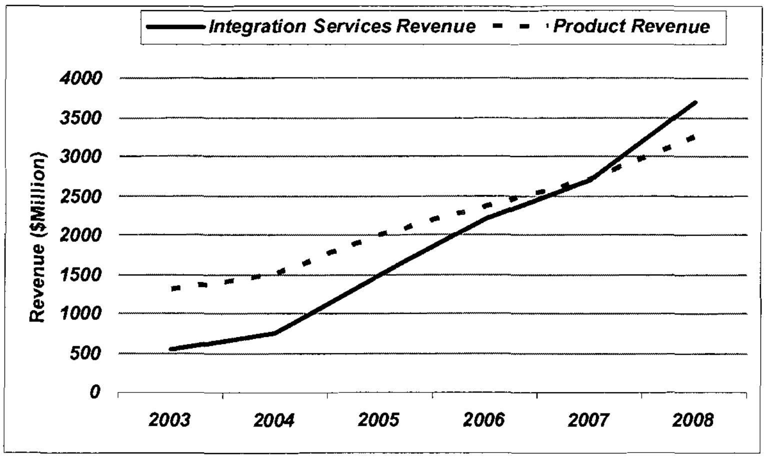
2.6.2 Tags/Transponders

Tag technology is changing quickly and the development of the new EPC Gen2 standard is advantageous for adopters. The creation of the standard increases the number of suppliers producing products, which increases competition. Some competitors are gaining market share through market penetration pricing and the price of Gen2 tags is now similar to Gen1. This drives adoption of the new technology standard which increases volume. Manufacturers intend to regain product margins once the technology matures and volumes increase (Gouthaman, 2006). Tag revenues should triple in value from 2004, and will reach $480 million by 2008. Of this, 61% of revenue will be from high frequency tags and 35% from ultra high frequency tags (Liard, 2005).

2.6.3 Services

In 2007, RFID integration services revenue will exceed RFID product revenue (see Figure 2.5, below). This is reflective of RFID market maturation driven by large software and system providers, such as Oracle and IBM that are investing heavily in the field. There is a levelling of product revenues because of dropping tag prices not a levelling of tag units. Sensor tags will positively affect product revenues. Although there are fewer sales of sensor tags, unit prices are higher (Nilsson).

Figure 2.5: RFID Product Revenue versus RFID Integration Services Revenue (World Market, Moderate Forecast: 2003-2008)



Source: Nilsson

The size of the RFID industry is growing due to rapid adoption and recent standardisation in tag technology. Recent consolidation by large competitors has increased industry rivalry, which has created a favourable situation for adopters. However, evaluation of on-going industry developments is prudent to determine their impact on technology standards and industry competitiveness.

2.6.4 RFID standards

A primary area of concern for many potential adopters was the apparent lack of global RFID standards. Although a lack of standards may hamper adoption in the highly-regulated and global aviation industry, adoption in some applications, such as toll roads, has not relied on the establishment of standards. Incompatible RFID standards exist in rail, truck, air traffic control and tolling stations, and standards even differ within between agencies of the U.S. government. Standardisation creates a network effect across the installed user base; as more companies use standardised tags and networks, more services are available to all partners. Conversely, a lack of standardisation has limited RFID adoption through the inability to exploit inter-industry economies of scale (Dowla, 2004). There are numerous standards organisations involved within the RFID industry but two agencies have taken a primary role in defining RFID standards: the International Organisation for Standardisation ("ISO") and EPCGlobal.

ISO is a non-governmental organisation that creates commercial and industrial standards. When a standard involves electrical equipment, ISO works with the International Electrotechnical Commission (IEC), which is the leading standards body for all electrotechnologies including energy production, electronics and telecommunications. ISO has created numerous RFID standards related to application and performance standards but has created only one RFID tag standard: ISO 18000 (ISO).

The Massachusetts Institute of Technology (MIT) formed the Auto-ID Center in 1999 through the support of the U.S. DoD and other consumer packaged goods manufacturers. The goal was to develop RFID technology in support of supply chain efficiencies. Eventually the group grew to include several universities, all of which sought a common vision of developing an "Internet of things". In 2003, the Auto-ID Center licensed the intellectual property to the group responsible for the barcode, the Uniform Code Council. They created a new division, known as the EPCGlobal, which would oversee the allocation of EPC numbers to end users (Sweeney, 2005).

EPCGlobal is now a non profit, industry-based organisation that seeks to establish global standards and subsequent adoption of its EPC technologies and network. While the Auto-ID centre is involved in research, the EPCGlobal divisions are involved in commercialisation of the technology. EPCGlobal has created the protocols and data structure of the most common tags, including those used by Wal-Mart and DoD. EPCGlobal has also created the Generation 2 ("Gen2") standard, which is a passive RFID tag that operates in the 860-960 MHz range (EPCGlobal, 2005). The inclusion of this standard within the ISO 18000-6C standard is one of the most significant recent events in the RFID industry. This was particularly significant for EPC as it now legitimises its product as a global standard. This certification has created momentum for the standard resulting in increased investment, development and adoption (RFID update, July 2006).

2.6.5 Radio frequency regulations

One of the challenges in creating a global RFID standard is the availability of a common, global radio frequency. Low, high and ultra-high frequency bands differ around the world, and the number of national regulatory bodies presents a challenge to developing RFID tags for global use. The International Telecommunication Union (ITU) is an agency of the United Nations that coordinates and regulates the use of the global radio spectrum. The ITU created three regulatory regions: Europe and Africa, North and South America, and the Far East and Australasia. Each region has their own frequencies, but there are also frequency bands common to all regions which reduce problems between bordering nations and allows for large global markets for products and services (Struzak, 2003). Within each country, national governmental bodies, such as the Canadian Radio and Telecommunications Commission (CRTC) and the Federal Communications Commission (FCC) in the U.S., regulate use of the RF spectrum.

Low and high frequency RFID tags can be used around the world without a license; however, UHF does not have a single global standard. In North America, the licensed UHF frequency is 902-928 MHz, while in Europe it is 869.40 -869.65 MHz. A common global UHF frequency is not currently possible as the North American frequency conflicts with the GSM band, Europe's cellular phone standard (Heinrich, 2005). This lack if consistency in the allocation of frequencies within countries creates few, if any, global RFID frequencies. This should change over time and there should be some uniformity between countries by 2010 (Dowla, 2004). However, a multi-band RFID system could provide a technological answer to regulations and the lack of global standards. Such a system would use multiple frequencies around the globe and would reduce the need to achieve a common global RF frequency (Heinrich, 2005).

Despite differences in global radio frequencies, standards and regulations, recent standardisation of the Gen2 tag presents a basis for global development and growth. This new era in standardisation should increase the number of RFID suppliers and customers due to the creation of a level playing field and freedom from manufacturer lock-in. Firms anticipating adoption of the technology must protect themselves from changes in standards that could impact their investment. Firms should ensure that the proposed architecture is standards-based; and, if possible, employs Internet standards such as Java or XML (Bhuptani & Moradpour, 2005). This should help to insulate the firm against purchasing a system that may be more susceptible to technological and standards changes.

2.7 Social Resistance to RFID Is high

A group named CASPIAN (Consumers Against Supermarket Privacy Invasion and Numbering) is determined to stop the proliferation of RFID use in society. They believe that once everything we own and interact with is in a database, unethical corporations and governments will track and monitor us. CASPIAN believes that RFID chips, which they call "spychips", will identify everything we purchase and will reveal too much private information without our knowledge or consent. CASPIAN cites IBM's 2001 patent application, "Identification and tracking of persons using RFID-tagged items", as proof that corporations are intent on doing more with the technology than ensuring store shelves are stocked (Albrecht and McIntyre, 2005). The first claim of the IBM patent application # 0020165758 reads:

> "1. A method of identifying characteristics associated with a particular person, the method comprising the steps of: storing transaction information associated with a plurality of different persons; collecting product information from RFID-tagged items carried on a particular person; correlating the product information with the transaction information; and identifying characteristics associated with the particular person based on results of the correlating step."

Consumers have several concerns with the technology and its impact on privacy. The primary concerns are: the consumer is unaware of the tag's existence; the tag's continued operation post-sale, and; the tag's ability to transfer information without the owners' knowledge or consent, including linking the person with their credit card information (Poirier & McCollum, 2006). While there is no slowing of RFID system adoption, the technology's effect on society will continue to grow as the technology becomes more prevalent and sophisticated as a result of the EPC database. Although this should be minimal in aviation applications, potential adopters should consider the social impact of the technology, and include a plan within their initial assessment to address employee and public concerns.

2.8 Summary: RFID Offers Considerable Benefits

RFID technology and functionality are increasing rapidly. Initial adoption may have resulted from mandates from powerful purchasers but supply chain and business benefits should not accrue solely to third parties. Firms that adopt the technology have an opportunity to modify work processes and realise significant gains in productivity well beyond the supply chain. However, prior to an investment, a firm must also thoroughly assess social concerns from members internal and external to the organisation. The intent of the investment is to increase productivity and decrease non value-added activities, and there is the potential for considerable employee unrest as roles and activities change. A firm should anticipate these changes, seek input from those affected and present a well-detailed plan that addresses the concerns.

Regulations affect RFID technology because of the use of nationally-regulated radio spectra. These evolve slowly and there may be little a firm can do other than to ensure the technology acquired can grow with the changing regulatory landscape. Gen2 Standards achieved in 2006 have provided some assurance of a secure foundation. As a result, enhanced innovation and economic factors make the technology more capable of meeting the needs of various industries, while increasing market opportunities for those within the RFID industry.

Following RFID requirements definition, an assessment of the technology is necessary to ensure it can meet those requirements. The firm must also determine what information is necessary and how it plans to acquire, monitor, store and act upon this data. Determination of standards, architecture and integration with existing organisational processes and technology is necessary. The proposed technology must meet mandated requirements, if applicable, and maximise inter-firm compatibility.

Ideally, the technology standard would allow maximum future growth and opportunity and minimum downside risk. This is a difficult result to achieve and is reliant upon pre-investment focus of business need, economics, standards and system design. The system design and implementation requires considerable effort but this is really only the starting point for future process development and their resulting efficiencies. RFID is a powerful and emerging technology that provides the granular data from which the organisation can learn and grow; however, RFID capability does not inherently provide process or operational efficiency.

With this greater understanding of RFID technology, including industry and market factors, the focus shifts toward the helicopter industry and the application of RFID. The next chapter presents a helicopter industry analysis and subsequent chapters discuss strategic alternatives for a typical firm and helicopter maintenance operations. These chapters provide the reader with the necessary information to evaluate RFID in helicopter maintenance operations.

3 ANALYSIS OF THE HELICOPTER SERVICES INDUSTRY

3.1 Purpose of the Chapter

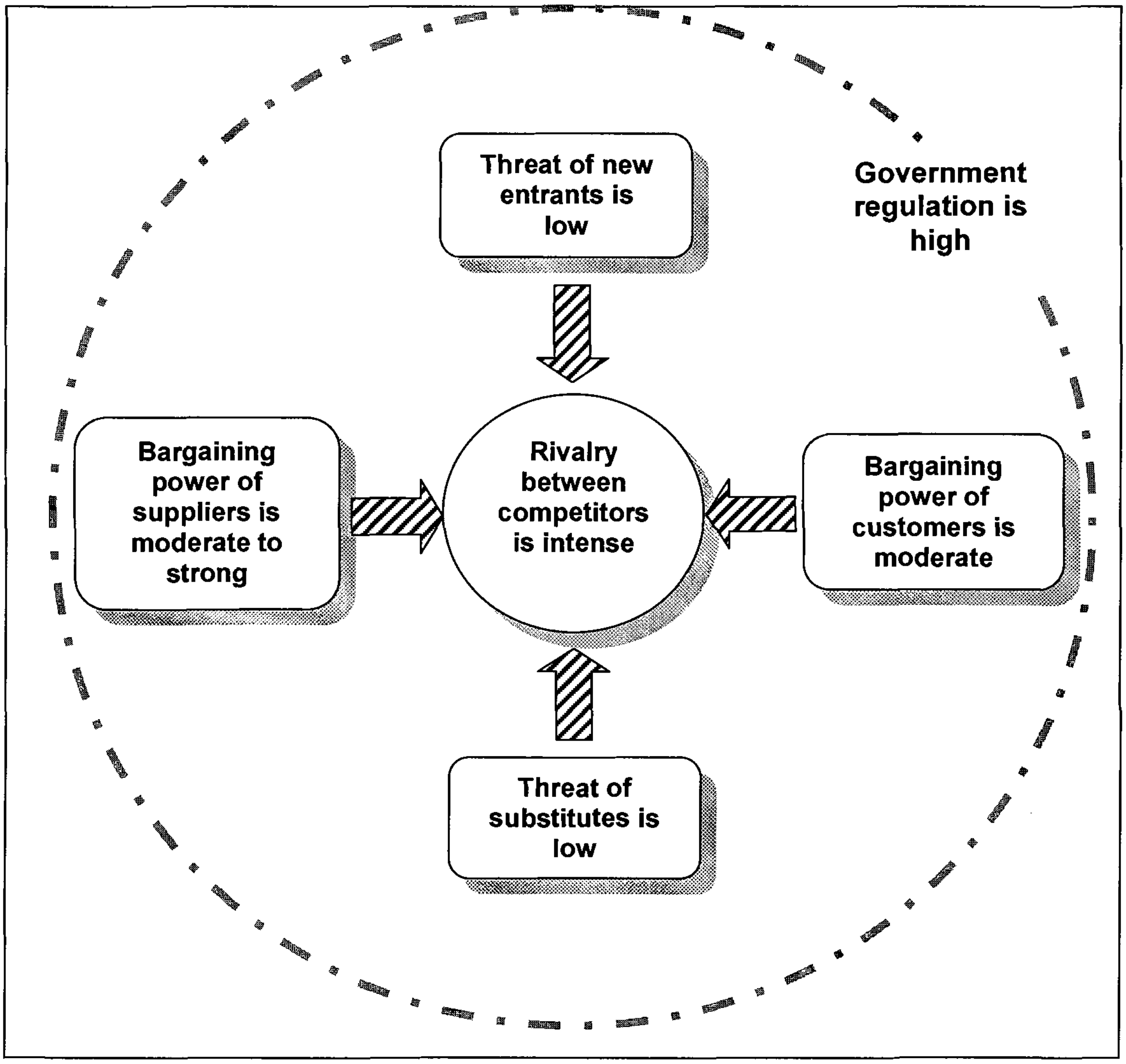
This chapter provides a brief overview of helicopter operations and presents an industry analysis on the global helicopter services industry. This analysis permits a greater understanding of competitors and factors of competition within the industry. With this understanding of industry competition, subsequent chapters present and assess the merits of alternative strategies, including the application of RFID technology.

3.2 Introduction to the Industry Analysis

This industry analysis reviews the factors affecting the provision of helicopter services to a global customer base. Firms competing in this industry are generally large international service providers that compete against other large industry firms for global contracts. However, they also compete against many small competitors that are competing in their local markets.

This analysis determines the attractiveness of the helicopter industry. The attractiveness of an industry relates to a firm's ability to earn rents and is determined through the examination of five forces: competitive rivalry, supplier bargaining power, buyer bargaining power, threat of entry of new competitors, and threat of substitutes (Porter, 1980). In addition to five forces found with Porter's Model, government regulations are also a major force and are included in this analysis (See Vining, Shapiro and Borges 2005, p.158 for additional information on government as a sixth force). Figure 3.1, below, illustrates these forces.

Figure 3.1: Forces Affecting Competition in the Helicopter Industry



Adapted from Porter, 1980

3.2.1 Helicopters

Commercial helicopter operations began in the late 1940s with the first commercial aircraft, the Bell 47. This simple machine played a leading role in the Korean War and in the television series based on the war, M.A.S.H. In a little over 50 years, helicopters have developed into a fast, safe and efficient mode of transportation; and in many situations, there is no substitute for the modern helicopter.

Helicopters are involved in a wide range of military and civil activities that include: public security (police, coast guard, search and rescue), exploration, forestry, tourism, industrial support and news gathering. Helicopters range in complexity from simple, two-place, piston-powered aircraft flown privately or in traffic monitoring roles to large, multi-engine giants capable of carrying dozens of passengers many hundreds of kilometres in darkness or poor weather.

Purchase and maintenance costs vary considerably depending on the complexity of the aircraft. Small turbine helicopters, known as light helicopters, are capable of carrying 5-6 people and cost approximately $1.5 million. Twin-engine medium and heavy helicopters can carry 9-26 passengers and range in price from $10 to $20 million.

Aircraft capable of flying without visual reference to the ground (instrument flying) have a significant amount of electronics and are more costly to operate due to additional maintenance and pilot requirements. Maintenance requirements are specified by the manufacturer or "OEM" (Original Equipment Manufacturer), the regulatory authority in which the company operates, and customer contracts. Unlike airplanes that only have rotating engines, helicopters have hundreds of dynamic parts. These include rotor blades, shafting, flight controls and numerous gearboxes; and most of these are subject to overhaul or retirement lives. As a result, helicopters are expensive to operate, and small operators must create maintenance reserves from hourly operating revenues to pay for costly engine or gearbox overhauls.

3.2.2 Nature of helicopter operations

Helicopter operations vary in scope, duration and location. Locations vary as operators can provide helicopter service to customers from the operator's base, a remote foreign base or a remote field location. Customer requirements determine the helicopter type, staging area, personnel and type of specialised equipment (air ambulance, crop spray or fire fighting equipment, etc.). Helicopter service contracts can be brief and last only fractions of an hour, or they can be decades long. These changing requirements and environments create logistic challenges for the operator.

Long-established bases may have resident personnel, while pilots and maintenance staff typically rotate through more challenging locations. There is also a steady exchange of parts and documentation between the main headquarter and remote bases. Serviceable parts and equipment ship out while unserviceable parts return for repair or overhaul. Maintaining current technical, company and regulatory documentation also requires considerable logistic attention.

When operating from its main base, operations are easier as there is usually access to the necessary people, equipment and facilities. Logistic challenges become more complex in foreign base operations, and become extremely complex in remote foreign locations as there may be limited access to transport sources, the Internet or phones. A base often consists of a hangar and office to support maintenance and operational activities. Base operations permit the operator to enjoy some scale effects as well as increased maintenance and customer service capabilities. Scale effects result from reduced spare part inventories, equipment and personnel. Bulk fuel also provides a scale effect as the operator can avoid expensive and inconvenient drum fuel. Locations serviced by ground or air transport allow greater logistic opportunities, which reduce the need for on-site inventories.

One of the greatest concerns for an operator is downtime, which is known in the industry as aircraft on ground, or "AOG". This situation usually results in increased cost, reduced revenue and damage to the firm's reputation of reliability. There are many cost drivers when an aircraft is AOG. The firm incurs cost with the replacement part, the personnel required to change the part, non-performance penalties, the heroic expediting by logistic personnel, and the part's rushed delivery to the aircraft, which may not be in a suitable location. The impact associated with AOGs is so significant that preventing or limiting their occurrence could provide a competitive advantage.

3.3 Rivalry between Existing Firms Is Intense

Rivalry between competitors is commonly the area of greatest concern in an industry. Rivalry generally increases when there are more competitors, the competitors are of the same size, the competitors are not satisfied with their current market position, the demand for services grows slowly, fixed costs are high, and when customer switching costs are low (Porter, 1980).

The provision of global helicopter services is a mature, competitive industry. There is significant market commonality between the firms' products as each operates the same type of commercial aircraft, and this commonality leads to increased competition. There is considerable rivalry amongst competitors which suggests the industry is not profitable because of a reduction in the ability to earn rents.

All of these firms agree that key success factors in the industry are cost, reliability, safety and quality of service provided; as well as reputation, customer relationships, and availability of preferable aircraft. Although the relative importance of success factors may differ between competitors, all firms agree these are important to their customers and are therefore the primary basis of competition. This commonality of key success factors reflects the lack of differentiation between competitors.

3.3.1 Key industry competitors

There are thousands of helicopter operators in the world but only a few are large companies with global reach. These companies have prospered by supporting global oil and gas producers and their offshore oil platforms. The largest global operators are ERA Helicopters, Petroleum Helicopters, Bristow Group, and CHC Helicopters

International (EADS). While there are many small operators that cooperate through joint ventures to compete with these industry leaders, these smaller competitors do not have the resources to compete on a global basis.

3.3.2 Era Helicopters

Era helicopters ("Era") has a long history of providing helicopter service since it introduced the first commercial helicopter to Alaska in the late 1940s. The company now operates 108 aircraft in Alaska and the Gulf of Mexico ("GoM") region.

Era focuses on offshore support in the GoM and Alaska, and also provides heli-tourism services from its Alaskan bases. Era is the number three supplier of offshore services in the GoM behind Petroleum Helicopters and Bristow. In 2004, SEACOR Holdings purchased Era helicopters to complement its marine support of offshore oil and gas. Era's ten largest customers account for only 45% of revenues, with no customer providing more than 10% (SEACOR).

3.3.3 Petroleum Helicopters

Petroleum Helicopters ("PHI") focuses on serving the oil and gas industry in the GoM region, and has done so since 1949. The company has over 2,100 personnel and operates one of the largest fleets of any helicopter company, although 75% of the fleet are light aircraft. PHI also provides air medical services through its transport of patients between hospitals and from accident sites.

The company has numerous bases that span the Gulf Coast region in the GoM. Although it has operated in 43 different countries, international operations are usually joint ventures with local firms. PHI serves international customers in Angola, Antarctica and the Democratic republic of Congo. Less than 10% of PHI's fleet is involved in international activities.

PHI competes against the other large operators internationally, and against both large and small competitors in the GoM market (CHC is the only large competitor that does not compete in this market). Domestic oil and gas customers account for 60% of 2005 revenues, and only 8% of revenues was a result of foreign operations. PHI has a policy of not paying dividends to shareholders and, since the company CEO owns more than 50% of the voting shares, the outlook for future investment and subsequent growth remains uncertain (PHI).

3.3.4 Bristow Helicopters

The Bristow group has been operating for 50 years and now comprises both Bristow Helicopters and Offshore Logistics. Bristow began in the UK in the 1950s, and Offshore Logistics started in the 1970s in the GoM. In 1996, Offshore Logistics purchased 49% of Bristow and the conglomerate renamed itself the Bristow Group in 2006.

Bristow operates in 20 countries and has 3,700 employees involved in support of its large mixed fleet. The parent company also provides offshore oil platform production management in an attempt to provide complete transportation, staffing and production management services to its clients. 170 of Bristow's aircraft operate in North America (154 in the GoM). The company also has 32 aircraft in South and Central America, 40 in Europe, 48 in Nigeria, 13 in Australia, and 12 in Russia.

The Bristow group is the second largest provider in both the North Sea and the GoM. The group has western and eastern hemisphere divisions. The western headquarter is in Louisiana, while the eastern headquarter is in Redhill, UK. The company has operations in other offshore oil producing regions including Australia, Alaska, Brazil, Nigeria, Mexico, China, Russia and Trinidad. Bristow is also involved in numerous international joint ventures with foreign firms. This approach allows Bristow to extend its services into developing oil and gas markets and also provides a low cost structure in some operations. These joint venture firms include Petroleum Air Services (Egypt), Norsk Helicopters (Norway), Aeroleo Air Taxi (Brazil), Helicol (Columbia) and others.

3.3.5 CHC Helicopters

CHC Helicopters International ("CHC") has the highest revenues of any helicopter company, and is the largest provider to the offshore oil and gas industry. CHC was born in 1987 when it acquired its founding companies. These companies were also helicopter pioneers and had been providing helicopter services since the 1940s and 1950s in Canada and Europe respectively, and since the 1960s in Australia, Africa and Asia.

CHC operates 215 aircraft in 34 countries that span all seven continents. CHC has its headquarters in Richmond, BC and has major operating bases in Australia, South Africa, UK, Norway and the Netherlands. CHC is the largest provider of helicopter services to the North Sea, which is the largest offshore market in the world. The company operates 17 bases in support of the North Sea market and approximately 70% of the company's revenues result from offshore oil and gas support. The company is also heavily involved in both onshore and search and rescue operations.

CHC focuses on markets that require long-term support with medium and heavy helicopters. It has a long history of quality and reliable service, and attempts to reinforce its position as a full-service, high-quality helicopter provider. Unlike its competitors, CHC does not operate in the GoM, as the aircraft used there are usually light to medium aircraft, and often under short-term contract. The company's strategy is to enhance its competitive position by maintaining its strong customer relationships and reducing costs, while preserving high standards of safety and reliability. CHC believes its competitive strengths stem from its global coverage, long-term customer relationships, experience, safety, modern aircraft and lower cost structure due to economies of scale (CHC). Table 3.1, below, presents attributes of these global helicopter competitors.

Table 3.1: Global Helicopter Competitors

	Bristow Group	**CHC Helicopters International**	**Petroleum Helicopters**	**ERA Helicopters**
Headquarters	Redhill, UK	Richmond, British Columbia	Lafayette, Louisiana	Houston, Texas
Revenues (2005)	$709M USD	$903M CAD	$363M USD	$137M USD
Operating Income	$73.8M	$73.6M	$14M	$138M (SEACOR)
Market Cap	$785M	$800M	$496M	$2,144 (SEACOR)
% Rev from Oil & Gas support	91%	67%	60%	"Significant" but not known
Aircraft Operated and (Leased)	331 (20)	240 (63)	290 (11)	108 (14)
Hours Flown (2005)	272,000	160,000	111,236	56,924
# of countries with operations	20	35	3	1

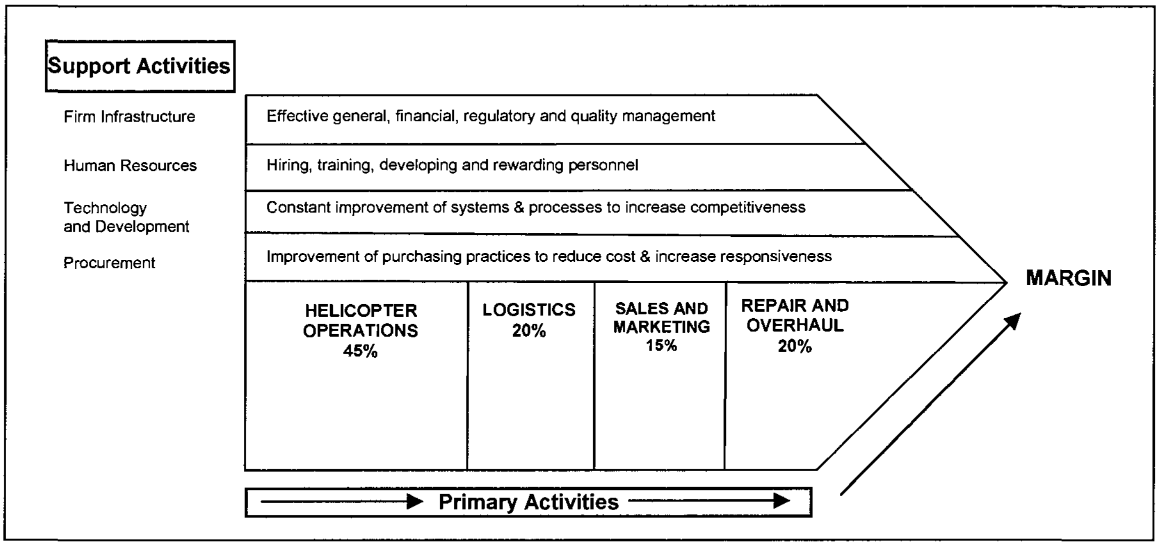
Source: Respective company website; Market cap data from Morningstar.com

3.3.6 How a typical helicopter firm creates value (value chain analysis)

Companies add value to inputs (products or services), and this value creation generates revenue. If the revenue produced exceeds the cost of creating the service, a company generates profit. A value chain separates the company into strategically relevant activities so they can be analysed for their contribution to a firm's cost or differentiation strategy. When a firm knows the source of its value creation, it can determine the competitive factors. From this, a firm can assess competitive advantage and determine ways to create and support it.

Nine value activities make up a company's value chain, and these are either primary or support activities. Primary activities are involved in the production of the service and include operations, logistics, sales and marketing, and repair and overhaul. Support activities provide infrastructure and support the primary activities. Support activities include firm infrastructure, human resource management, technology development and procurement. As a result of these activities, a firm realises a profit margin (Porter, 1985). Figure 3.1, below, is a generic value chain for a typical helicopter operator. The primary and support activities are representative of a typical firm in the industry, and the primary activities include an estimate of their overall contribution to value creation.

Figure 3.2: Helicopter Industry Generic Value Chain

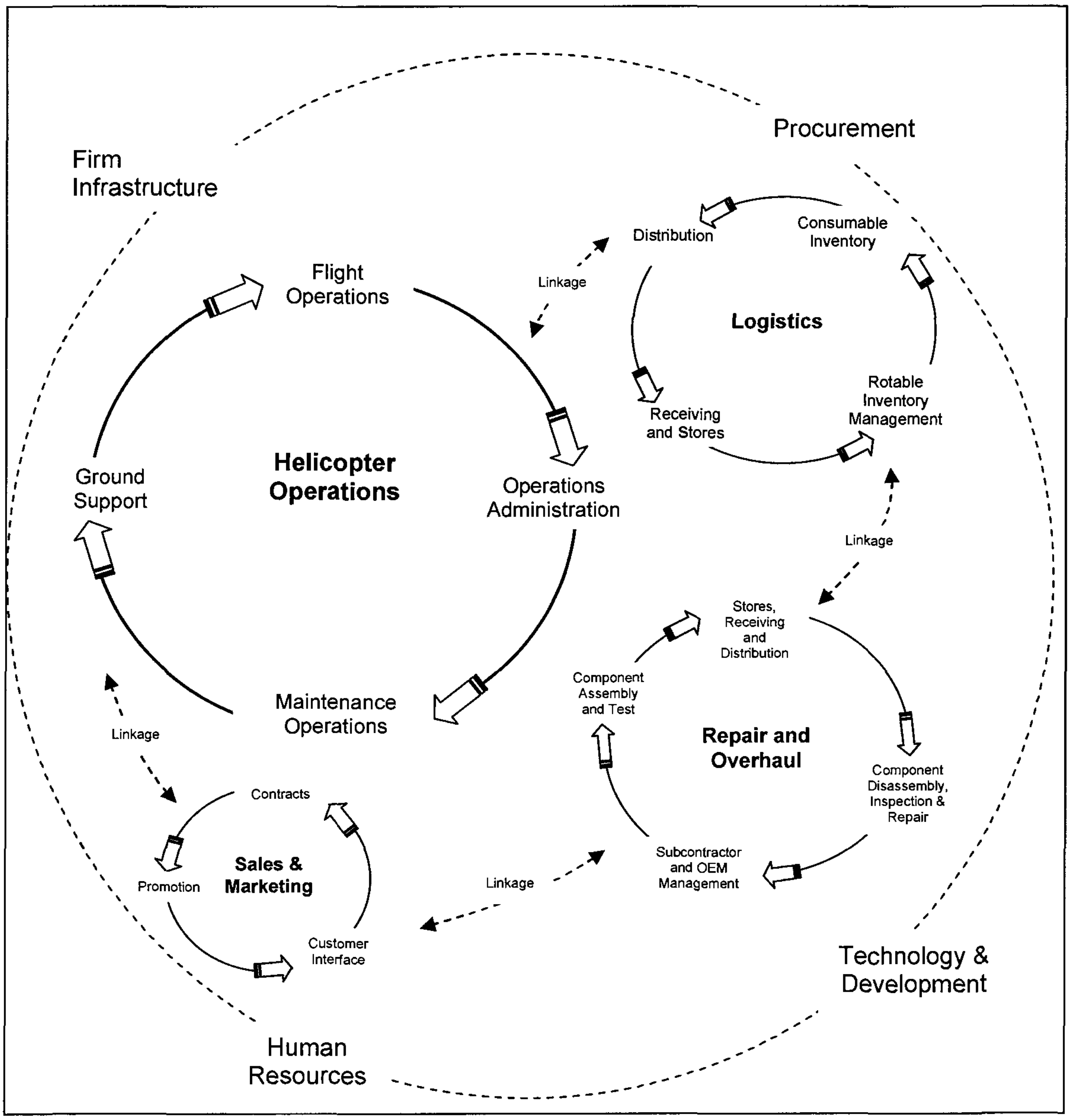


Source: Adapted from Porter, 1985, (pp. 33-50)

3.3.7 Primary activities

The most significant primary activity is helicopter operations. Operations activities include helicopter flight and maintenance operations, and, to a lesser degree, ground support and operations administration. These activities involve pilots, maintenance engineers, ground support and administrative personnel. Of these activities, only flight operations generates revenue, and all others contribute to direct or indirect costs. All large helicopter service providers perform at least some repair and overhaul services on their own products. This capability allows a firm to control overhaul costs, make their own decisions on overhaul quality (in excess of minimum OEM specifications) and manage their own production schedules. Figure 3.2, below, presents the primary activities and their interrelatedness as well as the overarching support activities typical of a firm within the industry.

Figure 3.3: Value Chain Activities Typical of a Large Helicopter Company



3.3.8 Support activities

The four support activities facilitate the accomplishment of the primary activities, although there are a number of discrete activities within every support activity. The first support activity is firm infrastructure, which includes broad management activities such as finance, accounting, quality, legal and general management. All of the major firms competing have some division of management functions between corporate and business-unit levels.

Human resource management is an integral support activity that involves recruiting, hiring, training, developing and compensating employees. Since the effective delivery of both primary and support activities is contingent upon personnel performance, this is an integral aspect of any company's competitive advantage. Additionally, if human resource management is not performed consistently across the organisation, varying standards and policies can occur which lead to inconsistencies and lower overall competitive performance.

Technology development includes process and knowledge activities. Research and development is not common in helicopter operations as modifications to OEM specifications and equipment are subject to regulatory control. As a result, firms must exploit technology and process improvement in other value chain activities (logistics, repair and overhaul, communications, procurement or support activities) to gain competitive advantage. Technology development therefore relies on the application of modified or improved commercial technology combined with operational or logistic knowledge to effect competitive advantage.

Well-developed procurement activities are essential to competitiveness. Since aviation regulations prohibit the use of non-OEM parts, competitiveness relies on process improvements as opposed to unique sourcing of products. Simple product acquisition cannot provide a competitive advantage, but accurate determination and handling of spare parts inventories and efficiencies in mobilising spare parts to grounded aircraft can. As a result, linkages between procurement and logistics are a primary source of competitive advantage. Table 3.2, below, presents a breakdown of a typical firm's significant activities within each of its primary activities. This disaggregation allows a greater understanding of cost drivers and linkages between value chain activities.

Table 3.2: Disaggregation of Primary Value Chain Activities

PRIMARY VALUE CHAIN COMPONENTS	DISCRETE ACTIVITIES	LINKAGES
HELICOPTER OPERATIONS		
Flight operations		
o Pilots	Flight training program, HR mgmt,	
o Fuel	Inventory control,	Firm Infrastructure,
o Approvals and licences	Foreign government expertise,	Maintenance
o Billing information (flight tickets)	Information exchange & billing	Operations,
o Ground personnel		Logistics,
o Dispatching	Training, HR management,	Sales and Marketing,
o Loading	Secure boarding facilities,	Human Resources
o Administrative	Billing, personnel management	
Maintenance Operations		
o Engineers	Training programs, HR mgmt,	Flight Operations,
o Tools and Equipment	Tool control system, quality mgmt,	Logistics,
o OEM tools and fixtures	Inventory control, vendor mgmt,	Firm Infrastructure,
o Hand tools		R&O
o Industrial tools		Human Resources
o Records	Tech. Record personnel, training,	
o Consumables (oil, grease, etc)	Inventory control, vendor mgmt,	
o Data and Information		
o OEM technical data	Tech. Library,	
o Company quality information	Configuration control, quality mgmt, training,	
o Maintenance records	Tech. Records department	
o Spare Parts		
o Facilities and Equipment	Appropriate stock levels,	
o Acquisition	Facility and equipment mgmt.	
o Maintenance		
LOGISTICS		
o Aircraft movement		Helicopter
o Spare parts	Distribution competencies	Operations,
o OEM & Industrial equip.	Global Inventory management	Procurement,
o Routine shipments and expediting	Vendor management	Firm Infrastructure,
(AOG)	Shipping regulations, dangerous goods,	Technology and
o Data	ITARs,	Development,
		Human Resources

PRIMARY VALUE CHAIN COMPONENTS	DISCRETE ACTIVITIES	LINKAGES
SALES & MARKETING		
o Customer interface (sales, complaints)	Customer relationship mgmt.	Infrastructure, Helicopter Operations
o Contracts (RFP/RFQ) acquisition and renew	Contract management,	
o Promotion	Marketing	
REPAIR AND OVERHAUL		
o R&O operations	Technical and repair technology expertise,	Logistics,
o Staffing	HR mgmt, training, quality management	Procurement,
o Production management	Inventory management	Firm Infrastructure,
o OEM and vendor parts	Tech. Library, Configuration control, Tech.	Technology and
o OEM technical data	Records personnel,	Development,
o Maintenance records	Vendor and regulatory quality system	Helicopter
o OEM, regulatory and quality approval management	competencies,	Operations, Sales and Marketing,
o Subcontractor management		Human Resources
o 3rd party customers		
o Sales and marketing	Marketing, Customer relationship mgmt.,	
o Billing	administration	

3.3.9 Industry factors of high seasonality, cyclicity and risk

Helicopter operations is subject to considerable seasonal effects due to weather and reduced daylight hours. In cold climates, there is a reduction in field activities due to difficulty of both helicopter and customer field operations. Low temperatures and frozen or snow covered ground can impede the customer's operations and therefore bias activities toward more moderate seasons. Cold operations usually mean reduced daylight hours, and the winter conditions can impact safe helicopter operations due to reduced visibility and aircraft icing. Even in moderate climates, seasonal weather can create hazards from storms and hurricanes.

Numerous external factors also create a highly cyclical industry. These factors include low oil prices, downturns in economies that limit exploration, political risk in oil-producing regions, terrorist activities and control of oil prices through adjustments in supply by OPEC nations. Fluctuating exchange rates and foreign governments seizing company assets, altering taxation or import/export laws, and repatriating earnings are also sources of risk common in many of the world's helicopter-intensive regions. There is also the constant risk of an aircraft accident. These aircraft are operating in some of the most challenging environments and a small error or unfortunate circumstance can have serious implications for a company, including the potential loss of revenue, personnel, reputation, or losses due to legal proceedings.

3.3.10 Competitor diversification is low

Operators attempt to ameliorate the effects of seasonality, cyclicity and risk through diversification. There are numerous ways to achieve this depending on the strategy of a firm. Some firms have expanded their scope beyond being purely helicopter service providers by offering a range of oil and gas services, while others have focused solely on helicopter transportation and related services.

SEACOR (Era) offers complete offshore oil support such as marine services, oil platform maintenance and operations, barge services, bulk transport and safety systems. This approach means that SEACOR is less dependent upon a strong helicopter industry to provide revenues, but the company is completely bound to offshore oil and is therefore subject to downturns in oil and gas markets.

Bristow is involved in two segments, helicopter services and production management, but is primarily bound to the oil and gas industry. The company purchased Grasso, an offshore production management company that operates over 300 oil and gas production facilities. Bristow is also involved in search and rescue and emergency services (law enforcement, disaster response, etc.), as well as training services for pilots, engineers, foreign and domestic militaries, and offshore production.

CHC has diversified little outside of helicopter services. The company is involved in search and rescue and coast guard operations and has contracts to provide coast guard services to with UK, Irish, Australian, Norwegian and African coast guard and search and rescue agencies. CHC's only diversification beyond helicopter services appears to be Mulitfabs, a cold weather survival suit manufacturer that provides products to offshore oil and gas, military and emergency services customers. This focus on helicopter services means that CHC is not bound to downturns in the oil and gas industry and can adapt its strategy to serve other markets as needed. However, CHC's lack of diversification beyond helicopters means that CHC has little to protect itself from fluctuations in the helicopter services market.

3.3.11 Firm consolidation is high

Like other industries, consolidation appears to be a common competitive strategy in the global helicopter industry. Consolidation can provide economies of scale and scope which can open new markets, limit risk, and impact costs and efficiencies in sales and marketing, distribution and training. However, companies still must ensure that there is congruence between strategy, organisational capabilities, core competence, and markets to realise a competitive advantage (Bukszar, 2006).

Apart from PHI, these competitors grew in size as a result of merger or acquisition of other helicopter firms. CHC has grown to the largest service provider by acquisition. Its most notable being Helikopter Service of Norway in 1999; and more recently, Schreiner Aviation of the Netherlands in 2004. These acquisitions have transformed CHC into the dominant player in the North Sea. Era is now part of a full-service offshore oil and gas support company since it was included in the operations of SEACOR in 2004. Bristow, too, gained size, capabilities and market reach through the merger with Offshore Logistics in 1996.

3.3.12 Helicopter operations requires high fixed cost

Providing helicopter services to a global market requires tremendous resources. There is the need for expensive aircraft, crews, inventory and equipment, and often in remote, foreign locations. Once on site, infrastructure is required for operations that include passenger handling and screening, maintenance and office facilities, fuel handling and storage facilities, as well as accommodation, transportation and communication technologies for the crew. While remote field operations require significant costs and logistic resources, there are many more cost drivers.

There are substantial capital requirements necessary at a firm's head office. Overhead costs are required for administration, sales and marketing, human resources, procurement, logistics, finance and management. Furthermore, a company needs to insulate itself from the inherent industry risk and, as such, there are significant costs relating to insurance.

The high capital costs in this industry are due to these many infrastructure and operating requirements. Competitors hold considerable assets compared to their company earnings. SEACOR has more assets than its competitors at almost $3 billion. This is followed by CHC ($1.75B), Bristow ($616M), and PHI ($224M). CHC employed assets valued at almost 25 times its net income. This ratio is similar to Air Canada (26:1), but considerably more than technology companies Microsoft (4:1) and Google (7:1).

3.3.13 Innovation in aviation is low

Innovation is the process that turns opportunity into new ideas and these new ideas into common practice. Innovation is typically associated with improvements that boost economic competitiveness. Innovation includes both radical change and small-scale incremental change, and differs from invention in that innovation includes commercialisation (Tidd, Bessant & Pavitt, 2005).

Core capabilities are unique and present the source of competitive advantage to a firm. These differ from supplemental and enabling capabilities, which could be contracted out and are therefore not suitably superior to those of a firm's competitors to offer a sustainable competitive advantage. Supplemental capabilities add value to core capabilities but competitors can easily imitate these, thereby negating the advantage. Enabling capabilities are necessary to compete but are not sufficient to distinguish a firm from its competitors (Leonard, 1995). Core capabilities are the most strategically important, followed by enabling and supplemental capabilities.

Core capabilities in this industry are helicopter flight operations, maintenance operations, repair and overhaul, and to a much lesser degree, logistics. The introduction of relational databases to manage the large flow of materials provided an enabling capability. All competitors now use similar database technologies and this technology is a necessary capability for competition. Pilot and technical training and development is also an enabling capability. Supplemental capabilities include essential communication and distribution technologies.

Because aviation is such a highly regulated industry, there is little opportunity for innovation with the helicopter or the provision of helicopter services. Although it is possible to receive authorisation for modification to an aircraft, most firms do not alter their aircraft as a source of innovation. Firms also do not operate or maintain the aircraft in a different manner, as the OEM strictly prescribes standards and parameters for these activities. Early pioneers did invent novel ways of using the aircraft to fight forest fires or install ambulance kits but competitors quickly replicated these innovations. As a result, there are few innovation opportunities within the primary activity of helicopter operations.

However, there are innovation opportunities in logistics through knowledge management and supply chain activities, and there are also efficiency and productivity innovations available in repair and overhaul through advanced repair technologies. Current market and competitive factors dictate that innovations are necessary to reduce cost and differentiate a firm from its competitors.

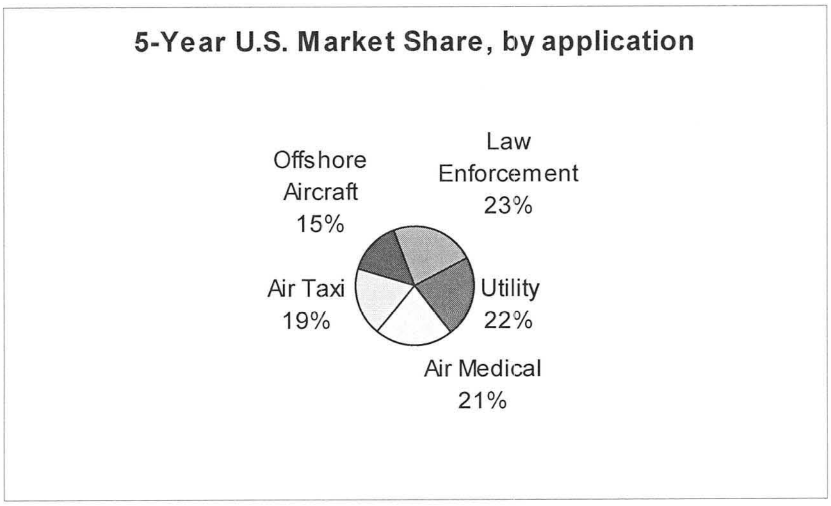
3.3.14 Helicopter markets

There are many markets for helicopter services. New markets evolve over time while some established markets contract based on economic and social factors. The military market is the largest for some OEMs. In many regions, particularly the U.S., the growth in that market has been motivated through military campaigns and strengthening of homeland security. While this market may have grown, the heli-logging market has slowed significantly since its rapid expansion in the 1980s and 1990s.

There are five dominant helicopter markets in the U.S.: law enforcement, utility, emergency medical services, air taxi and offshore support. The domestic law enforcement market was down in 2005 compared to 2002, but there are still 1,260 aircraft involved. The utility market segment includes fire fighting, tourism and exploration and comprises 22% of the U.S. market.

The emergency medical services market grew 6% in 2005 and involved some 700 aircraft. This market provides air medical support to accident sites and includes transfer of patients between hospitals. This is a large segment in the U.S. due to the private medical system and is not typical of the global market in this category. The air taxi market provides corporate and private transportation services. This market grew 3% in 2005. The offshore market is almost entirely in the GoM region and involves 15% of the helicopter industry and almost 700 aircraft (HAI). Figure 3.2, below, presents the proportion of market share by application.

Figure 3.4: U.S. Market Share by Application



Source: Helicopter Association International

In the global market for helicopter services, offshore support provides the greatest source of revenues. While small and medium helicopters can service the smaller and closer oil rigs found in the GoM, global energy customers rely on larger aircraft that are capable of flying farther and carrying more people, sometimes in known icing conditions. To compete in this global market, operators need larger aircraft. Table 3.2, below, presents the large aircraft held by the four offshore competitors. Two of the competitors that dominate the GoM market have few aircraft capable of competing in the North Sea or other typical offshore markets. As a result, Bristow and CHC dominate in the largest offshore market (the North Sea) and have the equipment necessary to compete in the world's other offshore markets.

Table 3.3: Holdings of Large, Offshore Helicopters, by Operator

	Sikorsky S-76	Sikorsky S-61	Sikorsky S-92	Eurocopter Super Puma
Bristow	52	16	1	33
CHC	59	26	2	48
Era	9	3		
PHI	21		5	

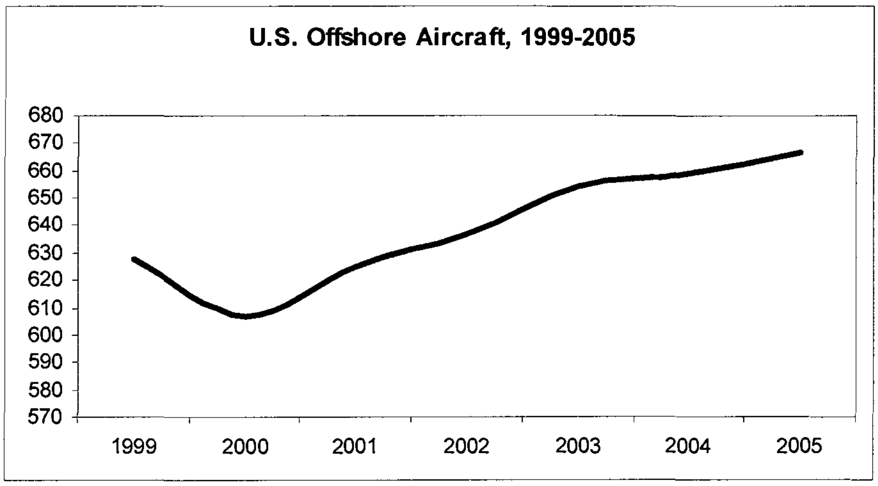
Source: Respective company website

3.3.15 Industry outlook is moderate

In 2005, there were over €7 billion worth of civil and military aircraft sold and this value will increase to €11 billion by 2010. There is demand for approximately 5,500 civilian helicopters between 2006 and 2015. In 2005, there were 580 civil turbine helicopters delivered and this rate should grow at an annual rate of 3% in the next ten years (EADS).

The helicopter industry is cyclical. The recent surge in oil prices has had a significant impact on new aircraft sales. Sales were poor and had been for over a decade, and it was not until 2004 that sales of new aircraft increased. With high oil prices, oil companies explore in more remote areas and new aircraft types are capable of servicing rigs farther offshore (Christie, 2006). While there is a correlation between oil prices and increased helicopter use, there will be some stabilisation within the industry as exploration normalises. However, the number of offshore helicopters operating in the U.S. has been increasing, and Figure 3.3, below, illustrates this trend.

Figure 3.5: Number of U.S. Offshore Aircraft, by Year



Source: Helicopter Association International

3.3.16 Summary: Rivalry in helicopter services industry is intense

Helicopter services is a mature, cyclical industry with both large and small competitors. Two competitors dominate the largest offshore market in the world and in other foreign markets there is ample competition from smaller operators. Industry growth is slow to moderate and competition is high.

PHI, CHC and Era have each recently grown through consolidation with other helicopter or oil and gas firms. These helicopter companies have gained new capabilities and synergies, and this has led to increased rivalries within the industry. The large competitors have diversified little beyond oil and gas support so when the energy industry does slow, there will be enhanced rivalry. Furthermore, competition increases when industry cycles through its low phase. The high asset value of the aircraft exaggerates this situation, as competitors attempt to keep their assets flying and producing revenue. As a result of these factors, rivalry between industry competitors is intense.

3.4 Supplier Bargaining Power Is Moderate to Strong

Suppliers demonstrate bargaining power through raising prices or altering quality or service levels. Suppliers tend to be more powerful when they are more concentrated than the industry they supply to, when they have differentiated products, and when switching costs are high due to customer investment in training, support equipment or ancillary products (Porter, 1980).

Suppliers to helicopter operators include helicopter manufacturers, fuel and lubricant companies, avionics (aviation electronics) manufacturers, insurance providers, basic aircraft hardware and consumable suppliers, and human resources such as pilots, maintenance engineers and support staff. The most significant of these suppliers from a competitive perspective are the helicopter OEMs and human resources.

3.4.1 Helicopter OEMs

There are only three principal helicopter manufacturers: Eurocopter, Bell and Sikorsky. Eurocopter is a French/German conglomerate owned by EADS (European Aeronautic Defence and Space Company), the large multinational that also owns Airbus. Sikorsky is American and has long been a supplier of large civilian and military helicopters. Bell is also American but its civilian division has its headquarters in Quebec. There are numerous other helicopter manufacturers around the globe although many of these are highly focused aircraft and do not enjoy the market share of these three market leaders. One such firm is Agusta/Westland, an English/Italian partnership that has recently produced several aircraft that are enjoying market success.

Helicopter OEMs actively compete for new aircraft sales. Historically, new aircraft margins have been very low but, once purchased, the OEM has another aircraft to support, and this support is for the life of the aircraft. Therefore, a low-margin, new aircraft sale can lead to long-term, high-margin aftermarket potential. One OEM executive said his company's goal was to achieve commercial aircraft margins of 5% (Persinos, 2001).

OEMs develop new aircraft types infrequently and most aircraft have lives that are many decades long. Since operators can rebuild older aircraft and keep them flying for a direct operating cost similar to new aircraft, there is little need to upgrade to expensive new machines. Unless contracts specify new aircraft types, most operators tend to stick with their depreciated older equipment, as it typically earns the same revenue per hour as a new aircraft. As a result, aircraft suppliers exercise the bulk of their power after the sale of new equipment. Large operators prefer to have a fleet comprised of different helicopter types. This allows the operator to meet the economic and service needs of various customers; and a diversified fleet can also reduces risk, as grounding of aircraft occurs for regulatory (safety) concerns and OEM parts shortages. This is in contrast to some airlines that prefer a homogeneous fleet for economic and operational reasons. Unlike airlines, helicopter companies must be flexible to meet the customer needs for many potential applications, including basic transportation, offshore all-weather capabilities, executive transport, external lift, air ambulance and fire-fighting.

3.4.2 Eurocopter

Eurocopter is the result of a 1992 merger of the small German firm, MBB, and the large French firm, Aerospatiale. Eurocopter has focused on model development and now has the most sophisticated range of models available. This investment has allowed the company to dominate and it now sells 76% of all new single engine helicopters in Canada (Eurocopter). The company's largest commercial aircraft, the Super Puma, first flew in 1978 and the latest generation of Super Puma can carry up to 24 passengers in known icing conditions. In the North Sea, Bristow and CHC operate 90% of the world's offshore Super Puma aircraft (CHC).

3.4.3 Bell

Bell produced the first commercial helicopter, the Bell 47, in the late 1940s. The company continued to win military contracts for its light and medium aircraft during the Vietnam War, and commercial success followed. These aircraft were dominant in commercial operations up until the 1990s when a lack of technological development had Bell losing ground to other OEMs.

Bell still sells the same 1960 technology aircraft that are safe and cost efficient. The company also produces modern light and medium executive aircraft. Bell has a large share of the small commercial operator market but for the larger operators, Bell's products only have significant market share in the Gulf of Mexico.

3.4.4 Sikorsky

Sikorsky has a long history in helicopter manufacture and has been building category-defining medium and heavy helicopters for over 50 years. It only produces a new civilian model every few decades but the aircraft are successful in their markets. Sikorsky's most successful aircraft is the heavy-lift S-61. First produced in the 1950s, the S-61 is capable of carrying 22 passengers. This aircraft also had a military version known as the Sea King, which is in service with many militaries around the world. Despite complaints of its age, few other aircraft could rival its capabilities.

In the 1970s, Sikorsky designed the S-76, a sleek medium aircraft capable of carrying 13 passengers. The aircraft was a success for executive transport and offshore support to smaller oil rigs. Unlike previous aircraft, the S-76 has had numerous updates as new engines and electronics have become available. As a result, Sikorsky has built 500 S-76 aircraft and it continues to lead the industry in this category.

In the past two years, Sikorsky has introduced the S-92, a long-awaited replacement for the S-61. 38 of these aircraft are now in service and they have already accumulated over 26,000 flight hours. The $20 million price limits the aircraft's adoption and application, but offshore customers are pleased with the sophisticated S-92's all-weather abilities and comfort. Sikorsky is also very active in the military market with its Black Hawk series of aircraft, and the U.S. military has over 1,500 of the aircraft. The S-92 is also finding a small military market and several nations, including Canada, have selected the aircraft to replace the Sea King. Unfortunately, Sikorsky lost out to Agusta-Westland in its bid for important U.S. military applications (Sikorsky). Despite Sikorsky's considerable success, the commercial market comprises only 15% of company revenues (Persinos, 2006).

3.4.5 Human resources

Helicopter operations is reliant upon highly-skilled pilots and maintenance personnel but the power of this group is cyclical. Although the current industry situation provides greater opportunities for these personnel, industry cyclicity will eventually have power shifting back to the employer. Some of the large operators have unionised workforces that better organise employee power, but this is not standard within the helicopter industry. Personnel who fly and maintain larger offshore aircraft have considerable experience. This means that the salaries of these personnel are higher than most others in the industry. While this places the large offshore operators in the enviable position of being desirable employers, it also means they must continue to offer higher salaries.

Some operators have implemented their own flight training facilities in an effort to both diversify and capture the best of the new pilot candidates (Bristow). However, newly certified commercial pilots can do little more than test flights as they lack the experience necessary to fly for most customers. As a result, these pilots spend five years or more and possibly thousands of flight hours as co-pilots before they command an aircraft (Rotor and Wing, August 2006).

Despite some concerns from operators that competition for workers has increased, a recent study indicates that average industry wages are up only 5%. Even though industry activity did increase in 2006, this did not necessarily mean an increase in salaries. However, CHC stated that its fourth quarter profit was down 37% due in part to recruiting and training costs for pilots (Rotor and Wing, August 2006). Human resource training costs are a significant expense to helicopter operators. The greatest expense is flight operations, as pilots require aircraft type training on each new aircraft and also require annual proficiency training to ensure competence. Maintenance personnel require factory-approved courses initially but do not require annual upgrading.

International standardisation of licensing has made it considerably easier for pilots and maintenance engineers to move within the global industry thereby increasing their power. Although the power of these professionals is substantial, their power is not necessarily any greater than other unionised, or even organised, workforces.

3.4.6 Insurance suppliers

According to a recent report, aviation insurance companies will soon be competing for new business and the result will be a reduction in insurance premiums. Until recently, only a few insurance companies serviced the industry but increased aviation activity, safety and margins have made the industry more attractive to insurers.

The insurance industry's attempt to gain market share may result in reduced underwriting standards; and this decreased focus on safety is counter to recent safety initiatives that have dropped accident rates and have given safe operators a break on insurance premiums. This means operator training, safety and operating standards may not be as important in securing the competitive advantage of reduced insurance costs (Rotor and Wing, June, 2006).

Insurance information for the large competitors is not available and it is therefore not possible to determine insurance costs as a percentage of revenue. However, it is felt that insurance costs are reflective of claims history, and access to suitable insurance is available to all competitors.

3.4.7 Regulations increase power of suppliers

The manufacturer controls all of the technical data and therefore details exactly what maintenance is required and when. Organisations cannot perform work if the relevant data is not included in technical manuals, or if the OEM does not provide explicit written approval. Performing work that is not OEM specified or approved is in contravention of aviation regulations. This situation allows the OEM to control what maintenance work is performed and by whom. A regulatory authority (usually the national authority of the country of manufacture) initially approves an aircraft based on its parts book contents. Aviation regulations prohibit deviation from the exact parts listed in the parts book. As a result, OEMs have regulatory backup that mandates the OEM as the only source of parts and specialised maintenance functions. Parts and maintenance data regulations provide monopolistic control and ensure the OEM is the only source for data and parts. The OEM can then extract monopolistic rents for parts and the performance of work that only it can provide.

Furthermore, OEMs entered the repair and overhaul market in the 1990s in an attempt to diversify when sales of new aircraft decreased. Since all of the large operators have some form of repair and overhaul authority, the OEMs compete with the operators for revenues in this market. Since the OEMs have the power to limit access to overhaul parts to the operators (who are now their competitors), they enjoy an unfair advantage and regulations support their position.

3.4.8 Summary: Supplier bargaining power is moderate to strong

Employee, insurance company and ancillary aviation supplier power is only low to moderate, but OEM power is strong. As a result, overall supplier bargaining power in the helicopter industry is moderate to strong.

There clearly is system lock-in once the operator purchases the OEM products, but operators have mixed fleets to diversify, reduce risk and attempt to keep the power of the OEM in check. OEMs can alter product quality and after-sale service levels, but reductions in these areas could impact their ability to sell their product within their own competitive market.

However, OEM power is greatest in the aftermarket where they can control competition and maximise margins on parts and services. The OEMs can determine when and if they ship parts to customers, and could slow part shipments to companies that compete with them in repair and overhaul markets. Unfortunately there is little an operator can do as aviation regulations fully support this unfair competitive situation.

3.5 Customer Bargaining Power Is Moderate

Powerful customers can pit competitors against one another and can demand higher levels of service and quality, as well as lower prices. When customers provide large sources of revenues, they can hold considerable bargaining power in price negotiations. This power increases in the helicopter industry as customers have knowledge of industry costs and pricing structure, there is more than one firm offering services, competitor fixed costs are high, and customer switching costs are relatively low (Porter, 1980).

Large helicopter operators often have multinational customers, many of which are global energy companies involved in the production of hydrocarbon commodities. These customers have the potential to provide a significant amount of work to the operator and, as a result, firms strive to meet their safety, quality and pricing needs. In many cases, these customers have their own helicopters and can provide their own helicopter services should they decide to (Bristow).

Although these energy customers have considerable power, they are also reliant on safe and reliable air transport. Energy customers have their own safety requirements that exceed government regulations and they realise the cost involved in meeting these standards. Additionally, accidents and loss of production have serious impacts on energy providers and these factors temper their push for low-priced services. Customers such as government agencies seeking to fill search and rescue or other para-public contracts place more importance on safety and serviceability than on low cost.

There are many North Sea energy companies including ConocoPhillips, BP, Shell, Talisman, Total S.A., Chevron, ExxonMobil, and others (Wikipedia). With only two helicopter firms competing in the North Sea, there are more customers in this market than competitors. This mitigates the power held by the customer and provides some control to the competitors.

Customer bargaining power varies by customer and region. As with many other businesses, there are both cost- and service-based customers, and the ratio and power of these customers shapes the local market. Some look for low-cost transportation services and others look for safe and efficient operation of new technology aircraft so that their high-value and safety-critical operations remain productive. As a result of these factors, customer bargaining power for global helicopter services is moderate.

3.6 Threat of New Helicopter Operators Is Low

New entrants to the industry bring additional capacity and increase competition in order to gain market share. When new entrants can easily enter a market, the attractiveness of that market decreases. Barriers to entry provide competitive insulation and limit the number of competitors within the industry. Barriers found within the global helicopter service market include specialised knowledge, learning curves, economies of scale, regulations and high capital costs.

Considerable capital is required for aircraft, crews, training, and the infrastructure necessary for onshore and offshore bases. There are also large economies of scale necessary to compete in the industry. These economies come from internal repair and overhaul capability, logistics, training, inventory, and from a broad range of global bases that allow for quick dispatch to new contract locations as well as knowledge of local customs and regulations.

Learning curve experience also presents a barrier to entry. With large fleets and decades of experience, the large competitors draw upon their technical and operational experience. Experience curves allow a reduction in unit cost which creates a barrier to entry as new competitor costs are higher (Porter, 1980). Such cost reductions exist in efficient maintenance activities that result following years of operational experience. Access to aircraft is another barrier to entry. The helicopters of choice in the North Sea market are the Super Puma and, more recently, the S-92 due to their range, carrying capacity and all-weather capability. CHC and Bristow operate 90% of the worldwide offshore fleet of Super Puma aircraft. A new entrant requires 18 months lead time to acquire one of these aircraft and this presents a further barrier to entry (CHC). As a result of these factors, most notably the high capital cost, barrier to entry, and the economy of scale factors, the threat of new entrants to the helicopter industry is low.

3.7 Threat of Substitutes to Helicopter Operators Is Low

The possibility of substitutes presents a threat to current competitors, especially when switching is relatively easy and the costs in doing so are low. However, there are few substitutes for a helicopter. Helicopters can efficiently reach areas that would otherwise be inaccessible, or that would take considerably longer or pose safety concerns through the use of other transportation means. In the case of offshore oil rig support, it could take a day or more to travel the hundreds of kilometres out to the rig and in rough seas, the safety of passengers and vessel may be jeopardised.

Fixed wing aircraft can travel farther and faster than helicopters but cannot land in small clearings or on oil rigs. Bell and Boeing have developed vertical takeoff and landing (VTOL) aircraft that act like fixed wing aircraft in flight but can hover like helicopters. However these aircraft have not been able to overcome technical difficulties and their potential threat to conventional helicopters is uncertain. Even if these aircraft were safe and fast alternatives to helicopters, helicopter operators would be operating these to complement their rotary wing fleets. So there is no threat of substitute providers, just a change in the technology employed.

There appears to be no imminent threat to the continued use of helicopters as a safe and efficient means of travel, particularly in dangerous environments. As a result of these factors, there is little concern for a threat of substitutes to current helicopter service providers, and the overall impact of this force is low.

3.8 The Regulatory Role of Government Is High

Aviation is a highly regulated industry. Government regulations control helicopter operations and specify who may operate and maintain an aircraft, and to what standard these activities are performed. There is little, if any, opportunity to deviate from regulatory requirements.

Every country has a national airworthiness authority that can dictate its own aviation policies. Domestically, this is Transport Canada. In the U.S., the Federal Aviation Authority (FAA) is the governing body while the European Union has the European Aviation Safety Agency (EASA). Many developing countries have either adopted the FAA regulations as their standard, or have their own standard based on the FAA structure and content. These national airworthiness authorities control certification of new aircraft as well as flight and maintenance operations. This means that countries around the world have varying regulations but it is not felt that these provide a source of competitive advantage for operators. Local authorities do not alter maintenance schedules specified by the OEMs for their products; however, local governments control operations and maintenance standards. As a result, certification requirements for pilots and maintenance personnel may permit greater operational flexibility, although this flexibility would be available to any competitor that operates under the rules of that airworthiness authority.

As mentioned in Section 3.4.7, regulations allow the OEM's complete control over their products. Operators are required to have all of the necessary maintenance and technical data provided by the OEM, and shall not deviate from the maintenance and operations procedures and standards specified. Furthermore, the operator may not use alternate products on the OEM's aircraft unless approved by the OEM or the national airworthiness authority.

Apart from aviation regulations, there are strict governmental restrictions on ownership and operational control of domestic companies, especially air service providers. For instance, the U.S. specifies that a U.S. citizen must own or control a domestic air carrier. There are many reasons for this, including national security and the access to domestic airspace, regulation of aviation bi-lateral agreements, and simple domestic industry protection (Furlan). Foreign ownership and domestic air operations restrictions are present in Canada and around the world. This is why most of the large competitors have subsidiaries or undertake joint ventures with local service providers. The International Civil Aviation Organisation (ICAO) promotes the liberalisation of the domestic air transport industry and many countries are reviewing their positions on this issue. These countries include the U.S., Australia, Russia, and the E.U.

The regulatory factors outlined above restrict the way the industry can operate but do not alter the basic competitive landscape or provide one region with an appreciable competitive advantage. Regulations do, however, provide OEMs with considerable power over the aftermarket, and this, too, is a factor that all competitors must face.

3.9 Summary: The Helicopter Industry Is Not Attractive to Enter

The provision of helicopter services to a global market is a challenging industry in which to compete. The industry is cyclical, involves high risk and requires major capital investment in aircraft, personnel, spares, equipment and facilities. There are considerable scale effects, learning curves and high barriers to entry resulting in a low threat of new entrants. There is a low threat of substitute products but there are some powerful suppliers. The OEMs compete with helicopter operators in the aftermarket and enjoy an advantageous regulatory position as there is no other authorised provider of parts, or in some cases, services. This moderate to strong bargaining power of the supplier is a challenge for all participants, but at least all competitors must compete in the same environment.

There are many regional competitors but only four firms are large and capable of competing on a global level. Of these, only CHC and Bristow are truly global in scope, as PHI and Era focus on American domestic services, primarily in the Gulf of Mexico. The rivalry between competitors is intense. There is little innovation which creates fewer sources for differentiation and value creation. Even though the outlook for the industry is positive, the return on capital is low. Because of these factors, there is a reduced opportunity to earn rents and therefore the global helicopter services industry is not attractive for entry.

4 ASSESSMENT OF CURRENT INDUSTRY SITUATION

4.1 Purpose of the Chapter

This chapter assesses the current industry situation and offers an alternative strategy to firms in the industry. Innovation in the helicopter industry is low but the application of technology may provide sustainable competitive advantage, which offers competitive insulation and increased returns for a firm. The adoption of RFID technology into an organisation's operations presents a valuable strategic approach that complements both cost-based and differentiation strategies. This innovation has the ability to reduce cost, increase efficiency and enhance activities throughout a firm's value chain.

4.2 Competitive Factors within the Industry

The industry analysis performed in chapter 3 determined that the global helicopter services industry is not attractive for entry due to the effect of industry forces. There is considerable competition between companies and substantial capital required to compete in this risky operational environment. The many aviation and government regulations restrict competitive activities (including innovation) and market entry; and there is considerable power in the hands of the OEMs who both supply these competitors and compete with them in repair and overhaul markets.

All competitors follow the same regulations for equipment, aircraft operations and maintenance. Competitors combine common inputs (OEM aircraft and parts, regulated pilots and maintenance personnel, and prescribed maintenance schedules) and attempt to compete based on a differentiated strategy, but with a significant focus on cost. This situation can lead to a "stuck in the middle" strategy as firms attempt to balance cost and quality. The cyclical nature of the industry creates competitive cost pressures that move firms away from a differentiated strategy; and this pressure increases when the industry slows, as firms attempt to service their considerable fixed costs.

The key success factors that differentiate competitors in the industry are customer service quality, aircraft serviceability and safety, and cost. These, often conflicting, factors must therefore form the basis of any strategic alternatives. Ideally, a solution that strengthens differentiated and cost-based positions for a firm is desirable. Such an approach would lower operating costs and improve safety and reliability.

4.3 Cost Control as a Source of Competitive Advantage

Cost control through efficiencies allows a firm to maintain or increase differentiated factors while keeping costs and shareholder returns competitive. For this reason, cost control in this industry allows a firm to pursue its competitive strategy with greater flexibility and resources, and provides a basis for competitive success. Ultimately, cost control provides a competitive advantage regardless of which generic strategy a firm pursues (Porter, 1985).

The challenge is to determine which value chain activities provide the greatest source of efficiencies, as well as potential competitive advantages. In general terms, streamlining of primary and support activities removes non value-added activities, while implementation of systems and processes increases efficiency and standardises routine activities. Efficiencies and effectiveness are particularly important in value chain activities that impact the three primary competitive criteria of aircraft serviceability, customer service quality and cost.

4.4 Challenges in Maintenance, R&O and Logistics Activities

Maintenance, repair and overhaul (R&O) and logistics are cost-intensive activities that directly impact serviceability and reliability. Modification of these primary value chain activities offers the ability to achieve both cost-based and differentiation strategies, which results in considerable competitive advantage for a firm. Maintenance operations, R&O and logistics are interrelated because logistic capabilities support the effective delivery of maintenance activities, and all three of these activities have a direct relationship with safety and reliability. There are considerable learning effects related to each of these activities and integrating the effectiveness between the activities enhances the competitive effect.

4.5 Technology as a Source of Competitive Advantage

Technology has a significant effect on competition. It impacts cost or differentiation drivers, which affect a firm's relative cost and differentiation position, and therefore its relative competitiveness. Technologies that allow a firm to accomplish a value chain activity more efficiently than its competitors provide a competitive advantage. Adoption of RFID technology supports both differentiation and cost-based strategies. The implementation of RFID complements either strategy by reducing cost and providing enhanced support to field operations, thereby offering greater value to customers.

4.6 Summary of Suggested Strategic Approach

Cost control and technology implementation support both cost-based and differentiated generic competitive strategies. Developing such a foundation allows a firm to maximise profits when industry activity is high, and allows a firm to compete effectively when cyclicity intensifies industry competition. Employment of an RFID strategy creates a competitive advantage for a firm as it enhances the prime customer concerns of safety, reliability and cost.

5 GENERIC STRATEGIC ALTERNATIVES FOR A FIRM

5.1 Purpose of the Chapter

This chapter details the strategies available to competing firms and analyses them for their potential impact on competitiveness. The preferred approach is the implementation of RFID technology to reduce cost and enhance aircraft serviceability and reliability. This chapter presents an evaluation of this and other strategic alternatives.

5.2 Strategic Alternatives

There are countless potential alternatives for firms competing in the helicopter industry but the focus remains on the industry's key success factors of reliability, service quality and cost. Therefore, a firm could: not alter its strategic direction and maintain the status quo; focus on cost control; focus on safety, reliability and service to provide greater market differentiation; or a firm could implement technology that could provide cost or differentiation advantages. There are also many other strategies available to a firm and these include operational specialisation, divestiture, or increased growth through acquisition or firm consolidation.

For the purposes of this analysis, the evaluation and subsequent ranking of strategic alternatives focuses on the goal of long-term profitability. This is not profit maximisation, which is generally short-term and can be in conflict with long-term, competitive goals. Capital expenditures are an example of replacing short-term profit for long-term competitive benefits.

The large firms competing in this industry have developed and detailed strategic plans that consider many internal and external factors. These plans detail the most effective means of achieving company objectives. Firms also consider broad-based social, technological, economic and political issues that could impact their competitiveness and continued success. The greater a firm understands its competitors, the industry and economic factors, the better it can anticipate and respond to increased competitive pressure.

These firms compete based upon differentiated strategies. They all agree that the key success factors are cost, reliability and service, and this common approach to strategic alternatives leads to reduced differentiation. As a result, the alternatives discussed below would result in a very slight shift along the generic strategy scale, either more toward a cost-based or differentiated strategy.

5.2.1 Strategic status quo

Firms could choose not to change their strategies and continue to compete for work based on their current strategies. This strategy may be cost-based or differentiated; however, it must address how the firm will continue to compete during times of increased competition that come during industry downturns. Regardless of which generic strategy a firm pursues, it must increase activity effectiveness to control cost.

5.2.2 Strategic shift toward more of a cost-based service

In this industry, such a shift can only be slight. High fixed cost and a low return on capital provides small margins for these industry competitors. While it is certain that cost control offers a competitive advantage that persists when the industry is either expanding or contracting, it is not clear whether customer service or aircraft serviceability decreases through these cost control measures.

There are several ways in which a firm could achieve cost control. Wages and capital expenditures on non revenue-generating equipment are often the first measures taken. A firm could restrain capital expenditures as long as productivity or continued customer service did not suffer. Management and administration wages may provide cost control, and streamlining roles and activities may allow for reduced personnel while maintaining service levels. However, altering the number of maintenance or flight operations personnel or increasing their activities may both alienate this important group and negatively impact safety. Such a cost-based approach would most likely come from a new competitor, as they attempt to gain market share. In response to such an action, competitors would likely separate themselves from the low-cost provider by focusing on their differentiated features and their history of safe and reliable service.

A cost-control strategy is preferred to a cost-based strategy. Cost control allows a firm to remain profitable even when faced with increased competitive pressure. Cost-based however, may sacrifice the other key success factors, particularly the critical issue of safety.

5.2.3 Strategic shift toward more safety or service differentiation

An increasing focus on safety and service is a potential strategy. The degree of competitive advantage realised is unknown but there is a possibility of much higher costs resulting in an overall reduction of profits. Like other strategic alternatives, this alteration of strategy would also represent only a slight shift as the competitors already focus on safety and service.

Even though data is available that indicates the safety levels of offshore aircraft exceeds that of commercial fixed wing aircraft, no firm in the industry would suggest safety could not be increased. It is not known which firm has the highest safety record, nor are the relative safety rankings of competitors known. If a competitor were already providing the industry's highest safety record, the strength of industry forces actively pushing them to further increase safety seems low. As a result, the strategic benefits of a move toward greater safety and service may not provide sufficient differentiation for some firms. Customers would respond favourably to reliability and service improvements but not at any cost. A firm still must offer a cost-effective solution, preferably supported by a reputation built on years of objective evidence that upholds their claims. Industry customers would prefer to benefit from enhanced service delivery resulting from increased internal efficiencies, as opposed to paying more for increased service levels.

Competitor response would vary depending on the firm, markets and aircraft. Some competitors have flight simulators that can offer safety and cost advantages, while others employ knowledge management systems and activities to enhance their differentiation. These advantages are not easy to imitate which means that effective competitor response may take considerable effort and resources. Shifting of a firm's strategy toward greater differentiation is possible but this is a long-term strategy that must be demonstrable in its effectiveness, and it still may not provide sufficient competitive differentiation for some firms.

5.2.4 Application of RFID technology

The application of technology has the potential to shift the competitive landscape in favour of a firm. Technology affects cost and differentiation drivers and can provide a sustainable competitive advantage. Current RFID technology has proven that it can provide greater logistic control and reduce cost within the supply chain. Its value in maintenance operations is only now being determined in the commercial airline industry but the outlook is positive as OEMs are working to create guidelines and standards.

The potential benefits of RFID in the helicopter industry are enhanced because RFID addresses the three challenging and interrelated activities of logistics, maintenance and R&O. The technology also positively impacts a firm's ability to provide the industry's key success factors of safety, reliability and cost. Furthermore, the implementation of the technology supports either generic competitive strategy. Technologies that are common across value chain activities provide linkages, and these linkages can cross the boundaries between a firm and its suppliers. RFID technology creates interrelationships between key value chain activities where none existed before.

Adoption of technology provides a sustainable competitive advantage when it satisfies all of these criteria: the change lowers cost or increases differentiation; the change shifts cost or uniqueness drivers toward a firm; a first-mover advantage results; and, the change improves overall industry structure (Porter, 1980). RFID meets these criteria because it: decreases costs and increases serviceability; scale effects enhance and shift cost and uniqueness drivers; adoption provides first-mover advantage between a firm and its suppliers; and RFID improves the overall industry structure through increased control of bogus parts and safety. However, RFID is a commercial off-the-shelf technology that is available to any of these competitors and it is unlikely that it will provide a sustainable competitive advantage. It will provide competitive advantages to a first-mover but as the technology diffuses, the relative level of advantage will decrease.

The adoption of RFID provides many efficiency and effectiveness benefits to a firm. It also presents a competitive advantage in an industry that lacks such differentiators, particularly as a result of technological innovation. The implementation and success of a small incremental innovation such as RFID can be more sustainable than large, visible breakthroughs, as these often attract industry attention and competitive response. Innovators prefer to sustain their technological lead. This is possible when the lead provides a cost or differentiation advantage and when innovation is continuous, thereby creating a moving competitive target. Technological leadership is the result of pioneering innovation within an industry and this innovation can affect any value chain activity. Although leadership is representative of a differentiation strategy, this is not always the case as the leader may be the first to innovate a low-cost process. The decision to pioneer is a conscious one based upon the ability to sustain the technological lead, and the advantage or disadvantage of being the first-mover (Porter, 1980).

Pioneering is desirable when there is a first-mover advantage. The first-mover has several advantages: they can define the rules of competition and in some cases the standards; they can take a reputation lead in the industry; and, they can move farther along the proprietary learning curve, which may result in a persistent differentiation or cost advantage. Although first-movers may face disadvantages due to the additional costs or potential risk resulting from low-cost imitators or technological change, this threat appears low as RFID technology is already well developed and successful in other industries (Porter, 1980).

There are first-mover advantages for a helicopter firm that chooses to adopt RFID technology. These results from the ability to take a reputation and knowledge lead, define standards in concert with helicopter OEMs, and move farther along the learning curve.

5.2.5 Summary of strategic alternatives

Firms have numerous strategic alternatives available but regardless of which strategy they pursue, it should support the industry's key success factors of cost, service quality and aircraft reliability. A focus on cost may restrict a firm's ability to compete on service quality and reliability, while a focus on differentiation may decrease cost effectiveness. Cost control and enhanced service quality and reliability are all possible through the implementation of RFID technology.

There is little innovation or technology exploitation within the helicopter industry and RFID can provide considerable competitive advantages for a firm. This technology impacts cost and differentiation drivers and allows a firm to accomplish value chain activities more efficiently than its competitors; in fact, the technology impacts 85% of a typical firm's value creating activities and provides interrelationships between activities where none existed before. This technology has the ability to supplement any existing firm strategy and enhance customer value while reducing cost and aircraft downtime. The technology also positively impacts a firm's ability to provide the industry's key success factors of safety, reliability and cost. For these reasons, RFID technology is the preferred strategic alternative. A detailed discussion of application challenges, costs and benefits of RFID in maintenance operations follows in Chapter 6.

6 AN RFID SOLUTION TO MAINTENANCE OPERATIONS

6.1 Purpose of the Chapter

This chapter describes maintenance operations and determines whether RFID technology can provide a strategic advantage to a firm involved in maintenance operations. This evaluation focuses on the global helicopter service industry. This is a unique industry and provides a credible assessment of RFID's ability to address maintenance operations challenges in other industries. Greater adoption in those markets will help drive innovation and cost reduction, creating a virtuous circle and further benefits for adoption.

6.2 Introduction to Maintenance Operations

Maintenance operations involves the performance and support of activities necessary to maintain operational equipment. The term "maintenance operations" appropriately highlights the interaction between maintenance and business operations. This is a vital activity to many firms as any interruption in equipment serviceability affects a firm's ability to seek rents with that equipment. Furthermore, the efficiency with which a firm can perform this function can lead to competitive advantage.

Maintenance operations is dependent upon effective control and provision of the many maintenance activity inputs. In addition to the equipment requiring maintenance, these inputs include maintenance personnel, parts, OEM maintenance data, support equipment, tools and component historical documentation that tracks the component operation and maintenance history. Maintenance operations is a challenging activity to plan, as equipment often fails or requires service prior to its scheduled maintenance activities. The complexity of this challenge increases when equipment capital cost increases, the equipment is mobile, and the equipment failure has a significant impact on a firm's customers. When capital cost of equipment increases, the cost of maintenance support equipment, technical personnel and spare parts also tends to increase. This high cost may be due to increased technology incorporated into the equipment or the need to meet higher regulatory or other performance standards. Mobile equipment faces greater maintenance challenges because of the need for remote servicing, as equipment, parts and personnel must be available to repair the equipment regardless of its location. These challenges are compounded when the distances increase; with remote international locations being the most difficult.

When equipment availability is vital for a firm or its customers, there is greater pressure on maintenance operations. In the case of a large airplane deemed unserviceable at the departure gate, there is an immediate effect on the hundreds of passengers and to the schedule of their subsequent activities such as connecting flights or appointments. The impact to the airline is far more than the cost of several hundred meal vouchers, and the true cost can be very difficult to estimate with certainty. Further, costs related to accidents can be almost impossible to estimate.

Preventive maintenance decreases the likelihood and impact of unserviceable equipment through systematic inspection, detection and correction of potential failures. Preventive maintenance differs from corrective maintenance, as it is not performed in response to a problem.

6.3 Maintenance Operations in the Helicopter Industry

Few industries rely on effective maintenance operations as much as the helicopter industry. Helicopters involve a significant capital cost, operate in remote locations around the globe, are highly safety-critical, are subject to vast regulatory and contractual control, and often support vast numbers of personnel. For these reasons, helicopter maintenance operations provide a comprehensive evaluation of RFID technology and its ability to offer strategic advantages to a firm.

6.3.1 The many inputs to maintenance operations

There are many inputs necessary to perform scheduled helicopter maintenance. These include the aircraft and personnel as well as significant amounts of technical data. Technical data includes current maintenance data from the OEM as well as aircraft flight and technical logbooks, and, where necessary, process standards and procedures. The technical logbook contains historical records of hundreds of parts and components that have a service life. When parts undergo replacement or maintenance, updating of their individual record is necessary to reflect the time (date and aircraft hours) and work carried out. This permanent record follows the component for its life, which is often decades long.

Other inputs include spare parts, tools and equipment necessary to accomplish the maintenance function. Equipment requirements are often specialised OEM tooling that has strict calibration and maintenance requirements, and the high price necessitates sharing the equipment throughout the entire fleet. Once the aircraft servicing or testing is complete, the equipment returns to headquarters or moves on to other operational bases.

Spare parts are expensive and established bases commonly have millions of dollars in inventory on site. The control of on-site products is essential to both continued serviceability and cost control. Obviously each aircraft needs consumable products as well as replacement parts for items that commonly fail and whose failure impacts aircraft serviceability. Correct determination of spare part inventories must also consider the time required to ship needed parts to the remote base. As shipping time increases, potential customer penalties for non-performance offset the cost of increased inventories. Further complicating the situation is the need to rotate parts from on-site inventory (with no certain usage) to aircraft with certain needs, as many aircraft parts expire over time. The large capital requirements of this inventory combined with its potential decreasing value places greater cost pressures on the logistics activity.

Operational experience (learning-curve economies) provides the opportunity to gather and use the maintenance operations information and knowledge gained. All of these firms have acquired maintenance operations information over their 50-plus years of operation; although the degree to which they gather, control and exploit their knowledge to increase competitiveness is not certain.

6.3.2 Logistic challenges in maintenance operations

Competing firms must be competent in both anticipating the need for a part based on the firm's operational knowledge of the aircraft as well as delivering parts to waiting aircraft. When economics prohibit on-site spare parts, the timely acquisition and delivery of parts are essential to support continued operations; particularly when the customer stipulates non-performance penalties.

Because of the number and value of necessary maintenance operations inputs there is considerable logistic pressure on a firm. Data, tools and aircraft parts constantly move between head office (or the global distribution centre) and the remote base, and any missing input can lead to expensive downtime. Furthermore, there is some instability to the inputs over time as their availability or status can change due to on-going firm activities such as training of personnel, recalibration of tools and equipment, and overhaul or scrapping of time-expired parts.

6.4 The Role of RFID in Maintenance Operations

RFID can provide many benefits to maintenance operations. In general, the technology can reduce costs by removing non value-added activities, increasing logistic efficiency, and providing additional fleet, maintenance and operations information to a firm. These superior operations translate into a competitive advantage as they improve the primary competitive factors of cost, reliability and service.

RFID continues to be an increasing strategic technology in support of aerospace and defence activities. The large defence contractor, Lockheed Martin, illustrated the increasing importance of RFID in aerospace logistics through the acquisition of the RFID company, Savi Technology, in June 2006 (Savi). The primary benefits to the adoption of RFID in maintenance operations include: tracking of company assets; logistic/supply chain management; maintenance operations efficiencies; and enhanced activity and asset visibility.

6.4.1 Asset tracking

One of the greatest capabilities of RFID is its ability to track and control company assets. This implementation requires the tagging of all company assets such as calibrated tools, OEM tools and other equipment, especially if they are subject to on-going calibration or maintenance requirements. Effective tracking is necessary to reduce tool inventory and costs, and can even limit aircraft downtime that can occur as maintenance personnel wait for necessary inspection equipment.

Recurring calibration is necessary for any measuring device that, if incorrect, could potentially affect flight safety. These measuring devices provide pressure, temperature, vibration, tension and dimensional information. The most common devices are torque wrenches, micrometers, calipers and dial indicators, and there can be thousands of calibrated tools in a large firm. Because calibration frequencies can be as short as every three months, there is a considerable amount of transfer from the field to the calibration shop.

RFID tagging allows personnel to locate the equipment within the facility, and this is particularly difficult in large overhaul centres as tools and equipment can move between different processes. Fixed RFID readers at entry points can provide information on which shop a tool is in while handheld readers can determine exact tool location within a particular shop. This simple application has tremendous advantages as a recent report stated that as much as 70% of technicians' time is spent locating the necessary tools, parts and materials (RFID Update, Nov. 2006). Furthermore, this capability assists in passing audits as OEM, regulatory and customer auditors need assurance that the tool or equipment that is due for its scheduled inspection or re-calibration is not in use within the facility. If the firm cannot locate the tool, the security of the quality system is in doubt.

6.4.2 Logistic/supply chain management

There are many cost and value drivers in the helicopter industry and it appears that logistics may provide a significant source of cost control and differentiation. Logistics is a complex and challenging activity that is the basis for many major costs. Direct costs arise from excess inventory (carrying) costs and unserviceability (penalty) costs. There are also the business costs associated with loss of reputation when aircraft are grounded, as well as the strategic costs of losing contracts due to lack of cost control. Logistics is also a key driver of value as it augments reliability, safety and cost reduction. Because of this, RFID in logistics is a primary source of competitive advantage.

Because many OEMs, aviation contractors and third party manufacturers already have RFID capabilities to meet U.S. DoD mandates, the adoption of the technology by helicopter operators should provide immediate benefits. Sikorsky, EADS (Airbus/Eurocopter), General Electric, Bell Helicopter, Allied Signal, Honeywell, and

Raytheon already have the capability to provide RFID visibility within the supply chain so neither difficult standard/specification development nor supplier education campaigns are required. In fact, RFID shipments may already be arriving, and an RFID infrastructure at a firm's facility could allow immediate exploitation of the technology and its related competitive benefits.

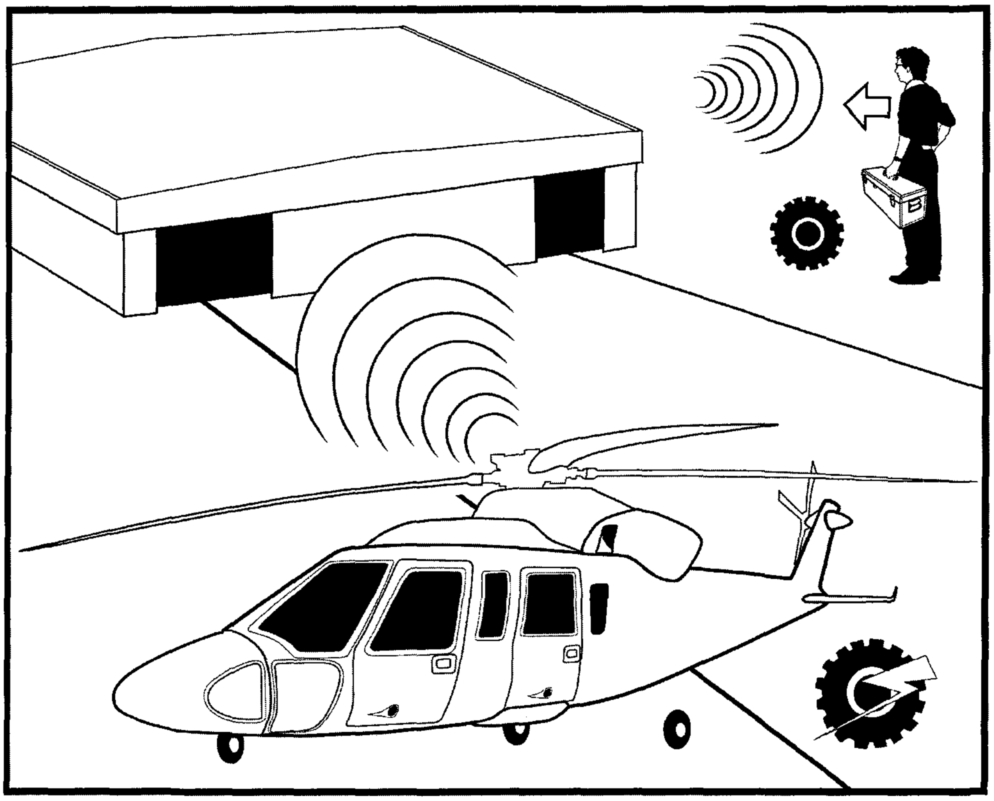
RFID improves part visibility and control, allows for additional sources of data gathering and decreases data gathering costs. In addition to providing greater visibility of products in the supply chain, RFID is particularly effective at tracking individual products that expire and this attribute integrates well with aerospace as most products have a limited life. Increased logistic effectiveness should provide increased productivity which may reduce downtime and unnecessary expediting costs. Strategically, the competitive cost to the firm for downtime is significant and minimising this results in increased customer value.

6.4.3 Maintenance operations and RFID

Apart from the obvious benefits associated with asset tracking and supply chain efficiencies, RFID enhances maintenance operations by altering the activities of maintenance personnel. The benefits result from reduced non value-added activities such as record updating and technical data acquisition. This is possible by providing RFID-based maintenance record and data capabilities to each part. These benefits are possible through the inclusion of RFID tags on replaceable aircraft components, commonly known as rotable parts. The tag on each component would provide the ability to record maintenance data and offer technical component information to maintenance personnel. Such a system would allow a permanent electronic logbook for each component and could supplement or replace OEM technical manuals. The design of such a system could take several forms: a tag could provide identification data that references a database of historical and technical information, or; a tag could provide all of the technical information without reference to an external source. This latter approach, using active tags, is taken by the DoD, as a high-speed Internet connection is not always available. However, Boeing and Airbus are pursuing stand-alone, passive (Gen2) tags to hold historical maintenance data.

Figure 6.1, below, illustrates how an RFID-enabled hangar would gather sensor information from the aircraft (a broken part) as well as supply chain logistic information from inbound shipments (the replacement part). The ability to merge requirements and logistics is core to the value creation of RFID in helicopter maintenance operations.

Figure 6.1: Hangar Acquiring RFID Data from Aircraft and Supply Chain



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6.4.4 Electronic logbooks with each part

There are numerous benefits to an electronic logbook. There is less likelihood of losing the component history log for each part, which could result in an automatic overhaul of the part and replacement of life limited parts. A less dire situation is the temporary separation of the historical paperwork from the component. This is a common occurrence as the part's (irreplaceable) permanent record of operational hours and maintenance history is held at the operator's main base and is updated by technical records personnel. When the repair and overhaul shop receives a component that was removed from the aircraft, the component is often held until this official paperwork is received. This work stoppage slows the overhaul process and results in the temporary suspension of several hundred thousand dollars in assets. An alternative would be for the technician to scan the tags of both the removed component and the overhauled component as well as the aircraft tag. This action could update relevant data without needless duplication of paperwork. Furthermore, technical records could receive a notification indicating the part's removal and complete the original paperwork so there is no delay in the overhaul process.

An electronic logbook could also increase flight safety by preventing unauthorised R&O facilities or unscrupulous parts distributors from updating historical records. The RFID tag and its security (encryption) protocols would present greater control over flight safety. Airline OEMs are pursuing this capability and regulatory agencies would support the introduction of increased control over parts that do not meet regulatory requirements (see Section 6.4.5, below). Another aspect of an RFID-equipped component is the ability to provide technical information about the component. This could drastically reduce the time required to source the information in the relevant OEM manual, and could even decrease the likelihood of incorrect information being used to maintain the product. However, tag capacity may limit this capability and comprehensive technical data may require the use of a referenced database.

A recent report suggests that the RFID market in aerospace and defence will exceed $2 billion in 2011, and the greatest opportunity will be in maintenance, repair and overhaul ("MRO"). The report states that the most challenging aspects are document control and control of parts, tools and materials. Recent efforts by technology companies have been in pursuit of so-called "integrated MRO", which provides visibility throughout the MRO process and can centralise sourcing, procurement, receipt and internal control. The report concludes that the essential aspect to integrated MRO is documentation and that RFID could automate processes, reduce labour and human error and facilitate the integration of disparate documentation systems (RFID Update, Nov. 2006).

There are other process advantages that can result once the technology is in place on the helicopter; however, these benefits are secondary and not solely due to RFID. Efficient ordering of replacement parts is possible by scanning the component's RFID tag. This allows the computer database to select an appropriate match for the component rather than have the technician pore over manuals to determine the correct part for that location. Furthermore, incorporating component replacement history within the database allows the development of maintenance operations knowledge. This knowledge develops organisational capabilities as the firm can more accurately anticipate future component demand for like products, and the firm also has a greater understanding of the true cost of its operations. Additionally, enhanced technical support is possible as component history is available to remote technical support personnel who can then provide greater assistance to field personnel.

The greatest benefit to RFID is its ability to integrate the many value chain activities within the helicopter industry. Unlike typical supply chain applications, the usefulness of the technology does not end when the product reaches the customer. A tag applied to an aircraft component can trace the product through the supply chain and can continue to provide enhanced capabilities throughout the component's life. These capabilities increase efficiency and reduce non value-added activities in maintenance operations, R&O, and incoming and reverse supply chains.

6.4.5 RFID developments driven by airline OEMs

The bulk of RFID adoption in aviation has been within the supply chain, although airlines now employ the technology to track diverse items such as food carts and customer baggage. Recently, OEMs have been developing innovative applications for the technology that include maintenance operations challenges. The first application of RFID in maintenance operations is beginning to appear with Boeing and Airbus, the two largest manufacturers of transport aircraft. These two aerospace giants have developed a common RFID strategy for aircraft manufacturing that also integrates with DoD protocols. The result is the continued entrenchment and development of the aircraft industry standard: ISO 18000-6C, which now includes EPC Gen2 (Porad, 2006).

These aircraft OEMs intend to use RFID technology on their next generation aircraft: the Boeing 787 and Airbus A350. Both OEMs are exploring the benefits of RFID-based data sensors and component identification tags. The OEMs intend to enhance after-sales service and product control, which are a constant concern for OEMs as they attempt to search out "bogus" aircraft parts that are a threat to both aircraft safety and OEM revenues. RFID can provide enhanced part control as only OEMs and authorised R&O centres can update the encrypted tags. Although not definitive, this additional hurdle for bogus part dealers may make misrepresenting parts uneconomical.

Boeing intends to reduce maintenance costs of its 787 airliners by 20% through the use of RFID tags on maintenance-significant parts. In total, 860 parts (2,100 different part numbers) from 50 suppliers (Honeywell, Rockwell Collins, Parker) will include RFID tags. The tags will include both a barcode and RFID transponders that will retain information on the part's serial number, part number, date of manufacture, weight, identification name and country of origin. Tags will retain maintenance information such as service bulletin compliance, date of overhaul and ongoing maintenance history, and will allow for updating as necessary. Boeing hopes this will decrease data entry errors and the number of suspected unapproved parts. As a result, Boeing believes this will decease risks and maintenance cycle time (Porad, 2006). For its part, Airbus intends to equip components on the world's largest transport aircraft, the Airbus A380, with 10,000 RFID tags to aid in logistics and maintenance operations (Poirier & McCollum, 2006).

Boeing and Airbus continue to develop additional competencies in RFID through testing and development. In cooperation with RFID providers, the OEMs have performed long-term testing of passive RFID on Fed-Ex transport aircraft in both identification and sensor installations. This and other work has resulted in the acceptance of passive RFID on aircraft by the U.S. Federal Aviation Administration (see section 6.5, below).

Despite the interest expressed by large aircraft OEMs, there appears to be little action thus far by helicopter OEMs. RFID in commercial helicopter applications seems obvious as regulatory agencies have accepted the application of RFID on aircraft and many aviation OEM suppliers (airframe, engine and accessory) already supply RFID-enabled shipments to the U.S. DoD. Development of RFID for helicopter components will require cooperation between OEMs and an adopting firm. It may be a challenging process to develop standards among the various airframe and engine OEMs, but the adopting firm has the opportunity to take a reputation lead, move farther along the learning curve, and could possibly alter standards in their favour. This cooperative development may result in first-mover and enduring competitive advantages for a firm. The only impediment appears to be the lack of motivation by the large firms in the helicopter industry needed to drive adoption. Compounding this is the lack of innovation and slow adoption of technology prevalent within the industry. As a result, development of RFID in the helicopter industry may be slow and driven solely by OEMs. This unfavourable situation may result in RFID standards and applications that limit maintenance operations benefits for the operator, and negate first-mover advantages.

6.5 Aviation Industry and Regulatory Approach to RFID

Aircraft operators and maintainers face far-reaching regulations that dictate activity requirements and performance standards. Almost every country has a national airworthiness authority that determines and enforces aviation regulations. There are also large aviation-industry agencies that provide a voice for industry participants. This section presents the position taken by regulatory and industry agencies on RFID.

6.5.1 Aviation regulations and RFID

Aviation regulations control the use of products installed on aircraft. RFID acceptance or approval from one country does not mean that an aircraft with RFID installed can operate in another country. Almost every country has a national airworthiness authority that dictates its own aviation policies. Some countries and regions have adopted the American aviation regulations as developed by the Federal Aviation Administration (FAA). European countries also have a powerful regulatory agency, EASA. This section presents the current position taken on RFID by the FAA, EASA and Canada's national airworthiness authority, Transport Canada.

6.5.2 The Federal Aviation Administration

The FAA in the United States approved RFID devices for the tagging of aircraft parts in May 2005. However, because the FAA had concerns that the devices could jeopardise flight safety, they have only approved passive RFID tags. The FAA has also only authorised frequencies other than approved aircraft communication frequencies, which does not disqualify the most common RFID tags of 2.45 GHz, 915 MHz and 13.56 MHz. However, tag interrogation is only authorised on the ground, and not while the aircraft is operational. The FAA is performing an assessment of active RFID tags for flight approval (Roberti, June 2005). This FAA approval is only for aircraft operated under their regulations and global acceptance requires approval from other national airworthiness authorities.

6.5.3 Transport Canada

Transport Canada is the national airworthiness authority in Canada and has created Canadian Aviation Regulations (CARs) to regulate its aviation industry. The current CAR relating to radio products is CAR 551.107, Radio-communication Equipment and 551.108, Radio Navigation Equipment. No regulation contains a reference to RFID technology, and Transport Canada has not yet addressed the issue of RFID in aircraft (Transport Canada).

6.5.4 The European Aviation Safety Agency

The European Aviation Safety Agency (EASA) is the airworthiness authority for the European Union. The agency presents a common strategy for safety and environmental rules but does not currently attempt to control member countries' approval of individual aircraft, maintenance or flight crews. EASA is not opposed to the installation of passive RFID tags on aircraft (EASA).

6.5.5 Aviation agencies

There are numerous national and international agencies that represent and regulate the aviation industry. Two of the largest and most influential are the Air Transport Association and the International Air Transport Association. The following sections present their views on RFID.

The Air Transport Association (ATA) is a trade organisation formed by 14 major U.S. airlines in 1936. The ATA is an interface between the airline industry and government and private sector organisations, and was instrumental in bringing deregulation to the aircraft industry. The ATA has developed an e-business policy that it calls "Spec2000". The goal was to revolutionise the multi-billion dollar aircraft parts business through standards, products and services. The ATA specification approved ISO 15693 (13.56 MHz UHF) tags for aircraft as they work well around metal products. However, this is at odds with Airbus and Boeing that prefer the EPC Gen2 standard that is common in supply chain management and soon to be employed in maintenance applications. (Roberti, March 2005). It is not certain whether ATA will modify its RFID policy in response to the recent acceptance of Gen2.

The International Air Transport Association (IATA) is a global trade organisation for air transport. Founded in 1945, Montréal-based IATA now represents 260 airlines in 140 countries that create over 94% of the world's international air traffic. IATA approved the use of ISO 18000-6C tags for baggage handling and identification in November of 2005, and supports the development of parts management applications for RFID. The association believes that the creation of an IATA RFID standard facilitates the acceptance of passengers transferring between airlines and also hastens the acceptance by control authorities. The focus of IATA appears to be baggage applications, but it is also in support of complementary applications within aviation (IATA).

6.6 Additional Maintenance Operations Markets for RFID

There are many other industries that offer potential markets for RFID in maintenance operations and logistics. If an industry can benefit from integrating the supply chain into its operations, it should evaluate the potential to create value with the adoption of RFID technology. More market potential for RFID equipment or service companies means that the maintenance operations sector becomes more attractive; capabilities and knowledge grows, and cost reductions often follow.

There are numerous potential industries including heavy equipment, ships, automobiles, medical equipment and others that operate maintenance-intensive or expensive equipment. Potential customers could include logistic companies, hospitals, cities, airports or universities. Although the potential list of industries is long, an analysis of industry competitive and economic factors is necessary to determine if RFID is strategically important.

The following section illustrates the impact that RFID technology could have on maintenance operations in the North American rail industry. If value creation were possible in that industry through the adoption of RFID, this would demonstrate the viability of the maintenance operations market to technology providers. Additional markets for the providers increase technology development and subsequent value, thereby creating further adoption. This indirect network benefit is advantageous to helicopter services companies or other RFID adopters.

6.6.1 North American rail industry and RFID

Almost all rail cars in North America have RFID transponders that speed car identification and sorting in congested rail yards. The Association of American Railroads created the initial tagging campaign in the 1980s and 1990s. Because of the technology infrastructure already in place, the peripatetic nature of rail cars and the potential safety hazards, the rail industry appears to be an obvious candidate for the integration of RFID into maintenance operations. Such an integrated system could provide asset tracking and usage management, condition monitoring, and operational and maintenance data.

Instead of the hotbox equipment found beside rail tracks that senses overheating wheel bearings, a simple RFID tag with a temperature sensor can monitor the temperature (and speed, direction, mileage) of every wheel, and transmit this back to central operations. Should a parameter be exceeded, the system could automatically order the replacement parts and schedule the appropriate person to attend to the problem with the necessary equipment and at the most logical location. The RFID reader directs the technician to the appropriate car, presents the maintenance data, updates the maintenance history for the car, creates an outbound label for the part removed for warranty or knowledge purposes, and even tracks the technician's time on each operation. Non value-added activities such as routine inspections could be eliminated or decreased if sensor networks could provide early detection and operational monitoring of impending problems. If these networks were integrated into a firm's operational database, ordering of replacement parts and scheduling of maintenance activities could also be achieved. This simple application demonstrates how efficient and safe rail operations integrate with maintenance operations to create a more effective organisation.

Some rail customers are attaching RFID sensors to their products to record the environmental conditions experienced by their product in transit. General Electric ("GE") has used rail to transport its large turbine engines but due to the cost and sensitive nature of the product, GE wanted to ensure that a negative effect would not result from the transport. GE used RFID tags attached to its products to measure temperature, shock, vibration, temperature, and humidity, while a GPS unit also relayed the unit's precise location (O'Connor, May 2006). Rail companies could create customer value and gain market share by offering this capability to their customers.

RFID sensors can increase railcar operational safety and efficiency, maintenance operations efficiency and effectiveness, and may even provide additional market share through increased value creation. The application of RFID in maintenance operations within the rail industry offers considerable economic and safety advantages and is a logical extension of the rail industry's existing RFID infrastructure.

6.7 A Phased Approach to RFID Implementation

A phased implementation of RFID reduces the strain on resources and allows a smooth introduction of system components. Implementing an RFID system on a smaller scale allows for evaluation of technology and processes. A phased introduction limits disruption to the organisation, focuses change management activities, and therefore increases success of the program. Following the planning phase, the first implementation phase is the application of RFID on company tool and equipment assets. The second implementation phase includes supply chain tracking by monitoring incoming and outgoing shipments, and the third phase includes tagging of rotable helicopter components. The last phase includes future development of sensor network technology that provides additional applications and sources of value creation.

6.7.1 Preliminary phase- planning

The planning phase is the largest and possibly most expensive phase. Considerable resources are required to determine the firm's needs, design the architecture and plan the implementation. For this, various consultants may be necessary, which can quickly increase the cost of the program. Consultants are required to assess the legacy enterprise resource planning (ERP) and supply chain management systems, and are also required to determine RFID technology requirements. The objective is to develop an effective system that permits future growth and flexibility while also providing minimal disruption to the organisation.

All requirements need to be determined and, as a result, a firm should have a clear understanding of the true costs and impacts associated with the project. The benefit is that no system components or process alterations are necessary until the consultants determine the infrastructure needed to meet the firm's demands. Furthermore, the costs are primarily front-loaded and on-going cost associated with tags and system maintenance is relatively small.

6.7.2 Phase one- asset tracking

Asset tracking is the logical first step in a firm's adoption of RFID technology because of the few operational hurdles and almost immediate benefits. RFID tagging of new tools and equipment is possible as they arrive, and tagging of current equipment is possible during their recalibration or maintenance cycle.

The firm must invest in appropriate tags, readers/antennae and software. Although relatively little cost is associated with product tags, readers and middleware are more expensive. As was stated in section 2.6.1, middleware extracts data, aggregates it and integrates the data into a firm's ERP program. The cost and complexity of middleware obviously varies depending upon legacy databases. Middleware is an expensive and complex component of an RFID system and the full range of current and future attributes must be determined before purchase. However, some ERP providers such as Oracle and IBM include RFID capabilities within their products so middleware acquisition may be unnecessary, or at least minimal. Fortunately, once operational, additional RFID capabilities are easily developed, and the cost is relatively low. The addition of new readers and tags can easily expand the system from its main base of operations to support its global operations.

6.7.3 Phase two- supply chain

The second phase of implementation should focus on the supply chain. Several airframe and engine OEMs and their suppliers already provide RFID-equipped shipments in support of U.S. DoD contracts, so providing the same functionality to their commercial customers should be simple. For those suppliers not currently providing RFID-enabled shipments, requests from their customers should not create insurmountable challenges, particularly with simple "slap and ship" labels. This phase also requires a firm to equip its remote bases and, if applicable, global distribution centres with RFID. This includes readers and tagging equipment for monitoring inbound and outbound shipments. Once in place, the RFID system can now provide global coverage and analysis of part movements and shipping time. Tracking of products within remote facilities is a valuable feature and this is possible through handheld readers.

At the completion of phase two, a company has developed the ability to monitor product shipments and company assets as they travel through the firm's logistic processes from suppliers to the main base, as well as to and from remote bases. This asset tracking and supply chain effectiveness can decrease cost and increase productivity in a firm, and provides the basis for development of RFID capability in maintenance operations.

6.7.4 Phase three- maintenance operations

This phase of the implementation includes the tagging of individual aircraft parts and could be concurrent with phase two. Although it is possible to perform phase three entirely in-house, the ability for external repair and overhaul facilities and suppliers to provide tag-equipped products certainly eases the indoctrination tagging necessary by internal company personnel. As a result, this phase should include work with suppliers to include RFID on their products, and the most obvious supplier is the helicopter OEM. Fomenting need and working collaboratively with OEMs can be desirable for a firm. Firm needs can be included into the architecture and standards, and the OEM acquires a partner in the development of a technological capability, which also provides value to the OEM. Customers, suppliers and competitors view this firm as the leader in this capability, which presents additional sources of competitive advantage and increases barriers to entry.

6.7.5 Phase four- future developments

Phase four allows for further development of a company-wide RFID capability. A firm that has reached this level of integration between its operations, logistics and supply chain is enjoying benefits that increase asset utilisation, and decrease inventory and non value-added activities and waste. Future developments have the greatest value creation potential and should include the ability for the aircraft to monitor its own operating conditions, alert when these conditions show unusual changes over time, and schedule resources to address this observed condition.

Helicopters already have expensive systems known as health and usage monitoring systems ("HUMS") that monitoring the aircraft for exceedances in vibration, temperatures or pressures. A logical extension of RFID (or other wireless technology) would be to develop a system that is lighter, cheaper and offers considerably more features than the current HUMS systems. This integrated HUMS system is one of the most exciting applications and has the potential to redefine aircraft operation and maintenance.

Ideally, incorporating RFID in all parts with maintenance or overhaul lives allows the system to track all parts and maintenance operations activities. These "smart parts" could contain all maintenance and operational history, alert the database when maintenance is required, integrate resources such as tools or equipment necessary to perform the function, record actions performed, update technical data, and monitor all activities that take place on the aircraft.

6.8 Economics of RFID in Maintenance Operations

This section presents a summary of typical RFID implementation costs and compares this, where possible, to the potential benefits realised by a firm through its adoption. The final determination of costs is dependent upon a firm's infrastructure, implementation schedule and scope. Benefits for all companies can be much more difficult to determine than costs, as benefits are sometimes qualitative and often indirect. A strategic imperative should drive the investment in RFID technology and this may not always be purely economic, as some indirect effects such as increased competitiveness may play a significant role.

6.8.1 RFID System costs

There are several sources of cost associated with developing an RFID capability. There are costs for tags, readers, antennae, middleware and system integrators, as well as the cost associated with employee training, maintenance of systems and equipment, and the cost of changing processes necessary to exploit the technology and its benefits. Other cost drivers include data storage costs (data warehousing), upgrade of ERP systems, process analysis as well as troubleshooting and consulting.

UHF readers typically cost $1,000-$3,000 and, in some cases, separate antennae are required. These can cost $250 each and may require cabling or other connectivity. Tag cost varies widely depending on application. EPC tags have an average price of $0.40 each, while tags housed in tough plastic housings which would be suitable for component application likely cost $4.00 each (RFID Journal, FAQ).

RFID middleware typically represents a large portion of the cost of an RFID implementation, but this may be changing. Only several years ago, the average middleware licence cost $125,000 but competition and other factors have dropped the price considerably. Average prices are now $5,000-$20,000, and there is even open source RFID middleware available (Nurminen, 2006).

Planning and consultation costs are likely the most significant. Depending on the scope of the implementation, the legacy systems involved, and the number of processes altered, consultant costs can be considerable. Although thorough planning of system needs adds to front-end costs, a reduction in problems and cost in the long-run can easily offset these early investments. Complete system costs were well over $1 million in recent years but $300,000 to $500,000 now appears to be a more common. Depending on the features sought from the global supply chain, a subscription to EPCGlobal's database may also be necessary and this can cost as much as $75,000 per year. This subscription allows the creation of EPC codes but this capability is likely limited to manufacturing organisations (Maurno, 2005).

In addition to these annual costs, tags and system maintenance should also be budgeted. 50 shipments per day at the current cost of $0.40 per EPC tag could add close to $75,000 per year. Consultants and system maintenance could cost several hundred thousand dollars, resulting in a total annual cost of approximately $250,000. Based on these estimates, implementation and one year's operation of RFID technology for a helicopter service company is likely between $500,000 and $1,000,000.

6.8.2 RFID system risk

There are many sources of risk present in an investment in RFID technology and a thorough risk assessment is necessary. The risks involved are primarily technological, economic, regulatory and social. The greatest of these is technological risk. It is possible that the firm selects the wrong technology, the system design could be inadequate or it may not integrate with a firm's legacy systems. Middleware systems may provide too much data and a firm may be unprepared to handle or respond to the data. Much of the technological risk relates to the system integrators and their ability to design a system that meets the needs of a firm without unnecessarily modifying activities.

Economic factors are obviously critical, although complete cost and benefit determinations may not be possible until the planning phase is complete. There is a minor concern with changing and emerging regulations. Approval for active tags on aircraft may not be forthcoming and global technology and radio frequency standards may alter the ultimate success of a current technology.

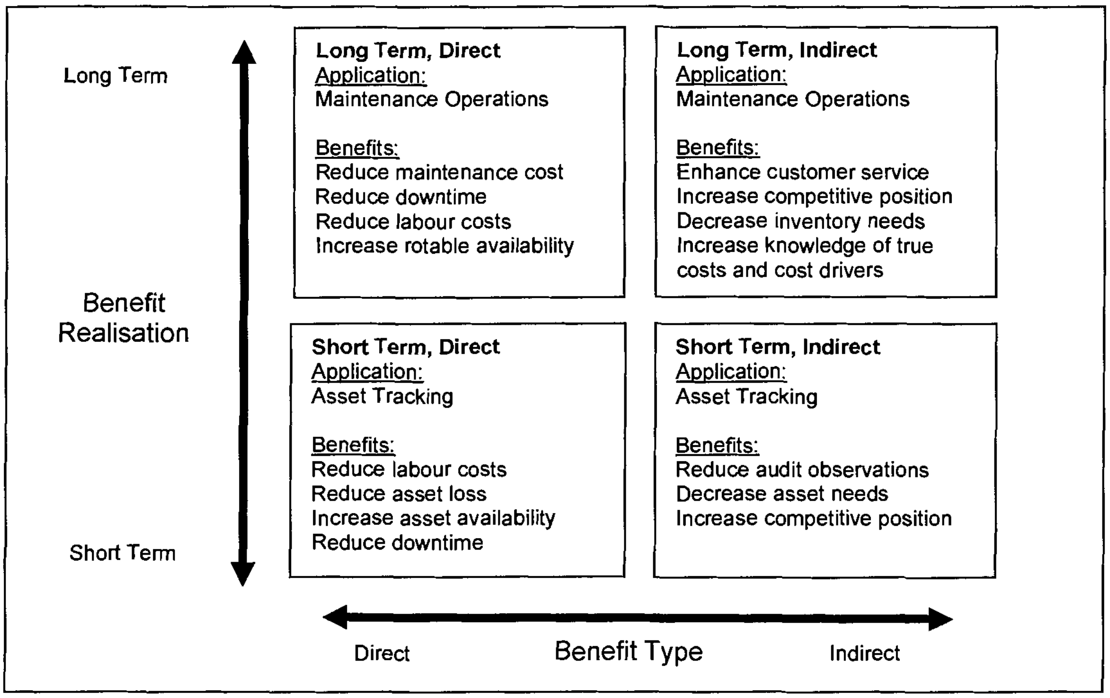
Other risks relate to a lack of OEM involvement, which could limit further expansion and benefits. Although unlikely, competing technologies could be involved in licensing disputes that could leave adopters with a dead-end technology or expensive on-going licensing fees. Social aspects create only a minor concern in aviation as maintenance personnel are familiar with the highly-regulated nature of the industry and the need to monitor and control their activities in the name of flight safety. Because of these factors, a firm considering such an investment would be wise to complete a technology and risk assessment.

6.8.3 RFID system benefits

There are numerous benefits associated with the introduction of RFID in support of helicopter operations. This section reviews the qualitative and quantitative benefits available to the firm as a result of adopting RFID technology in asset tracking, supply chain and maintenance operations.

Both direct and indirect benefits accrue over time and ideally these should exceed initial and recurring costs. Figure 6.2, below, illustrates some short-term direct and indirect benefits from RFID in asset tracking, and long-term direct and indirect benefits from RFID in maintenance operations. All proposed implementation areas offer short- and long-term benefit timeframes as well as direct and indirect benefit types.

Figure 6.2: Direct and Indirect Benefits that Accrue over Time



Source: Adapted from Bhuptani and Moradpour, 2005

In some applications, RFID offers only a marginal decrease in data entry costs. However, the prescribed application of RFID in helicopter maintenance operations goes well beyond this benefit. Asset tracking allows increased tool utilisation which leads to reduced tool needs. RFID tracking also reduces the time needed to locate tools within the organisation. Airbus incorporated RFID in tool tracking in 1997 and realised an increase in asset availability and a 25% reduction in turnaround time (Albright, 2005). Since most firms have thousands of controlled tools, this tool reduction represents $25,000- $50,000 in tool inventory costs. Further benefits result from their being 25% fewer tools to track, control and calibrate; and reductions in the estimated 70% of time technicians spend looking for tools and supplies.

The primary benefit of RFID in supply chain management is the ability to track spare part assets, monitor use, and determine asset needs, which may result in a reduction in part inventory. Other obvious benefits relate to enhanced visibility of products in the incoming supply chain and a reduction in non value-added activity; benefits typically found in current RFID supply chain applications.

RFID in maintenance operations presents many economic and competitive advantages to a firm. This capability permits greater value creation by integrating maintenance operations into a firm's supply chain. This speeds part ordering and transfer, and increases knowledge of product use and consumption. There is also a reduction in non value-added activities such as data transcription and repetitive communication of logistic information.

Quantitative benefits are difficult to determine precisely but the following example illustrates the effect of aircraft downtime. CHC has 240 aircraft that generated $903M in revenue in 2005. As such, the fleet generates $2,473,920 in revenue each day, or $10,308 per day for each aircraft (based upon equal fleet contribution). Each day an aircraft is not flying while waiting for tools or parts, CHC loses over $10,000 in revenue, and this does not include a performance penalty (if applicable) or the indirect cost of loss to reputation. If CHC implemented RFID and this could reduce aircraft downtime by just one day per year (approximately ¼ of one percent), it would save almost $2.5 million annually. Considering CHC has assets valued at $1.75 billion, a $400,000 investment amounts to only 0.02% of assets, and would provide a cost-effective means to control assets and increase its competitive position.

Another quantitative benefit can be determined from equipment and its use. CHC has over $50 million in equipment to support its operations. If RFID could increase equipment availability or decrease loss this would present a valuable benefit for the firm. Assuming a similar effect (¼ of one percent) on equipment availability, the firm would save $125,000 per year; and this does not include reduction in loss or the need for reduced inventory.

Qualitative benefits are also realised as a result of the technology implementation. Additional information is available for a firm and this provides greater understanding of activities and cost drivers, and therefore offers management increased control over its operations. The information can automate repetitive functions, increase responsiveness and decrease costs associated with shipping, personnel and inventory. A firm with this technology can develop its knowledge management system, create additional barriers to entry and increase customer value.

RFID also creates process efficiencies resulting from less non value-added time for technical personnel related to data acquisition, transcription and activity recording. Direct entry of needs into ERP systems reduces repetitive data entry and errors, and creates greater visibility of maintenance requirements. Efficiencies also result from reducing the cost (frequency, expediting and loss) of shipments. Some benefits are realised during the implementation phases previously discussed, while some are a result of future developments and process synergies resulting from the system implementation.

Table 6.1, below, presents an example of benefits and cost drivers for asset tracking, supply chain and maintenance operations.

Table 6.1: Benefits and Costs Related to RFID in Various Applications

Asset Tracking			
Direct Benefits	**Indirect Benefits**	**Cost Drivers**	**Comments**
Greater asset use Reduce tool administration time Reduce time spent locating tool Reduce loss of tool/equipment	Reduce assets required Reduce downtime Fewer audit observations	Implementation of system Tags on tools/equipment Training	If no further application were intended, a simple RFID system could accomplish this task. Specific RFID asset management middleware is available.
Supply Chain			
Direct Benefits	**Indirect Benefits**	**Cost Drivers**	**Comments**
Greater visibility and control of supply chain Faster ordering Track product expiry dates Reduce inventory needs Reduce downtime Reduce number of shipments Reduce labour	Increase customer value Decrease penalties Enhanced competitive capabilities Reduce extra communication	Tags required per product Complete RFID system required (middleware, consultants, etc.) Training On-going maintenance EPCGlobal subscription	Incoming products may already be tagged. Committing to this level of implementation requires complete system infrastructure
Maintenance Operations			
Direct Benefits	**Indirect Benefits**	**Cost Drivers**	**Comments**
Integration with supply chain and ERP system Monitor personnel activities/ product movements Reduce labour (less time looking for data, routine inspections, recording activities, etc) improve asset use (decrease R&O hold-ups) Increase serviceability through monitoring Transform business processes	Increase customer value Decrease penalties Enhance competitive position (tech. leadership, first mover, OEM partner in tech development, barriers to entry) Increase flight safety Knowledge mgmt. system can benefit from the data provided	System/tag testing and certification Development of protocols (poss. with OEM) Training of field personnel	This ability integrates assets, parts and activities for maximum benefit of RFID implementation.

RFID provides increased information that permits greater management control of operational, logistic and maintenance operations. Access to more granular and current information allows a firm to monitor more closely and respond faster to requirements or changing situations. Visibility of assets and field activities offers considerable advantages, and a common searchable database of previously disparate data sources allows greater knowledge management capabilities.

A comprehensive analysis is obviously firm-specific and the scope depends on the nature of the operations and existing infrastructure. The greatest potential cost of an RFID system could be middleware, although some firms may currently have an ERP system that could handle an RFID system. Not all firms have widely-spread bases and some don't rotate parts and equipment through their main base. In these cases, RFID in asset tracking or the supply chain may provide fewer benefits. Regardless of these inter-firm differences, the average cost to a firm of lost revenue is similar, and an advantage that decreases downtime of these expensive assets is worthy of detailed analysis.

6.9 Summary of RFID in Maintenance Operations

RFID has proven that it is effective in supply chain applications and complementary applications are now emerging. Aviation regulatory and trade agencies have responded by approving the technology for use in the industry. Aviation is adopting the technology for supply chain management and airline OEMs will incorporate the technology into new aircraft to reduce costs and enhance maintenance operations. EPC Gen2 has emerged as the global standard, which provides a basis for technology development.

RFID can increase competitiveness by removing non value-added activities, increasing logistic effectiveness and improving fleet, maintenance and operational information. The proposed implementation began with asset tracking before expanding to supply chain management and, finally, maintenance operations. This phased approach allows testing of system components and gradual development of RFID capabilities which decrease the resource requirements and ensure a smooth introduction of the RFID system.

Helicopter maintenance operations requires a continual exchange of parts, equipment and data. Effectiveness in the control and performance of this activity results in increased aircraft serviceability and employee productivity. Furthermore, maintenance operations spans 85% of the value creation of a typical firm, and improving maintenance operations performance is essential to continued competitiveness. RFID provides greater information flow while reducing repetitive non-value tasks. This allows a firm to make a more informed decision and respond quickly to changing situations. Visibility and monitoring of assets reduces inventory and turn times.

RFID provides opportunities to reduce cost, increase revenues and create an enhanced competitive position. Development of a broad RFID capability requires significant resources. Besides the considerable financial resources, company personnel are necessary during planning and development phases, and all personnel involved in logistics and maintenance will need training. Estimates for such an implementation could easily top one million dollars; although, depending on current ERP systems, an RFID capability could be available for much less. Benefits are possible immediately and over the long-term. Such benefits result from cost savings while some indirect benefits do not offer quantifiable monetary advantages but rather contribute to a firm's competitive advantage. An integrated RFID system provides greater product and process visibility and improved decision making; optimised part and asset inventory levels; improved integration of the supply chain into maintenance operations; lower handling costs, loss and theft; and improved productivity of technical and administrative personnel.

7 KEY ISSUES AND RECOMMENDATIONS

7.1 Key Issues

This chapter reviews key issues presented throughout this analysis that impact the determination of whether RFID can enhance maintenance operations within the helicopter industry. There are several key issues within this analysis related to RFID technology, the helicopter industry and maintenance operations that support the determination of whether RFID provides a firm with an enhanced competitive position.

RFID is an enabling technology that can incorporate passive objects into IT infrastructure. This facilitates more intelligent decision making and thereby creates efficiencies, increases process and quality control, and reduces cost. Adoption and development of the technology has been rapid in recent years and the growth of the RFID industry creates further development of standards, capabilities and applications. RFID now provides wireless monitoring of people, activities and products, and can even employ sensor networks to monitor equipment operations and maintenance needs.

Helicopter industry competitive factors are cost, reliability and service. Rivalry, capital cost, cyclicity and regulation are high in this industry, and, as such, it is not attractive for entry. There is low innovation but additional value creation opportunities are possible within the primary value chain activities of operations, repair and overhaul, and logistics. Firms require a competitive strategy that augments the differentiated factors of service and safety and also provides cost competitiveness when cost pressure is high. RFID technology supports and further integrates the three interrelated primary value chain activities of a generic helicopter firm. RFID increases effectiveness and therefore provides a competitive advantage in asset, supply chain and maintenance operations management, and also addresses the three competitive factors of cost, service and reliability. Viable applications in other industries offer indirect network benefits related to cost, service and technology for adopters.

The cost and benefit of an RFID implementation presents competitive advantage opportunities. Benefits are both immediate and accrue over time; and, although not all are quantifiable, they do contribute to a firm's competitive position. A comprehensive RFID system can cost over half a million dollars but can create advantageous returns by increasing operational effectiveness and utilisation of a firm's high-value assets.

7.2 Strategic Recommendations

A company that can gather greater and more current information can be more responsive to changing market and operational conditions. Increased responsiveness reduces the likelihood and duration of downtime and the associated negative impacts to essential competitive factors of cost, reliability and service. RFID provides additional information to increase responsiveness and can also increase efficiency and productivity. Since cost control and enhanced reliability and customer service are essential to a firm's competitive position, RFID can provide a competitive advantage.

Information technology supports effective helicopter operations and RFID can provide information on products within the external and internal supply chains, and can also incorporate maintenance and operational data. The scope of the data collected and the integration of the data allows more effective management of the enterprise. RFID is a proven technology that offers increased information and process efficiencies. This analysis has determined that RFID offers a strategic advantage for this industry application and recommends its adoption. The generic recommendations are as follows:

1. assess firm infrastructure to determine scope and challenges with RFID adoption;
2. implement RFID incrementally as competencies increase;

3. monitor and improve processes as a result of increased data.

A firm must evaluate its current infrastructure to determine the scope and cost of an RFID implementation. In addition to assessing the technology's integration with existing systems in the firm, determining the scope of anticipated and potential capabilities prepares a firm for future capabilities and clarifies the true costs and benefits related to the investment. Middleware is the largest challenge and should be standards-based and capable of growth as technology, standards, protocols and business needs evolve.

Phased implementation allows a smoother introduction and greater control of processes. The most obvious first phase is asset tracking within the main maintenance facility, which will immediately improve productivity and is possible with minimal infrastructure. This introduction also allows testing of middleware integration on a smaller and controlled scale. Implementation of supply chain and maintenance operations capabilities should follow.

The real value to RFID is its ability to gather and share information across the extended enterprise. This is an important aspect, as a global helicopter company needs to incorporate more than just the supply chain to exploit the benefits of the technology. Maintenance operations involves the internal control and distribution of data, parts and equipment, and this aspect affects 85% of the value chain of a typical firm: helicopter operations, logistics and repair and overhaul. The compounding effect of incorporating maintenance operations is the greatest source of value creation for RFID, and this is necessary to realise maximum competitive advantage.

Not all of the gains realised are technological as some result from re-developed processes that the technology promotes. Reduction in non value-added activities increases productivity, and greater asset utilisation reduces inventory needs.

Furthermore, management can now access and benefit from data that was previously unavailable. A firm can assess and allocate true costs of equipment and activities associated with helicopter operations, and this insight allows the firm to be more competitive.

7.3 Conclusion

This analysis sought to determine whether RFID could provide a competitive advantage to a helicopter service provider through its ability to improve maintenance operations. The success of industry competitors is reliant upon their ability to provide safe and reliable helicopter transport at a competitive price while providing sufficient customer service. This analysis recommends the adoption of RFID because of its ability to increase firm competitiveness.

RFID can provide increasingly granular information to an industry that relies on acquiring and acting upon internal operations and supply chain data. The implementation of this technology enables a firm to support, understand and manage its operations through greater insight and connectedness between value chain activities. The benefits include faster response to issues, greater productivity, reduced cost and enhanced aircraft serviceability. These benefits strengthen a firm's position with regard to the industry competitive factors of cost, reliability and customer service. As such, RFID provides the firm with a competitive advantage.

While RFID is only one part of a larger IT system, it does offer advantages beyond reductions in data entry costs. RFID can help locate expensive parts and equipment, and because it provides information without access to a database, it offers greater capabilities than other Auto-ID technologies such as barcodes. Furthermore, sensor functions offer the possibility of enhanced operations with reduced need for routine, non value-added inspections.

RFID is a commercial off-the-shelf technology that is available to all competitors and the competitive advantage may decrease as the technology diffuses within the industry. However, the initial adopter may still enjoy enduring competitive advantages as a result of being the first-mover. As is evident in the consumer goods industry, laggards will adopt the technology so as not to lose competitive advantage; and application of RFID in the helicopter industry offers considerably more value creation opportunities than those in the supply chain.

There is little innovation in the helicopter industry and any innovation is typically outside of helicopter flight or maintenance operations. However, RFID can affect almost all aspects of a firm's operation: it increases the amount, exchange and integration of information across the firm's activities, and creates interrelationships between key value chain activities where none previously existed. In fact, it is the interrelatedness of the value creation activities combined with the logistic and operational challenges faced in the helicopter industry that necessitate greater operational information and control. RFID provides greater control of assets and activities that reduces cost and increases aircraft serviceability. The result of RFID adoption is increased financial and competitive advantage, and these factors are critical to the success of firms competing in this challenging business environment.

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