

CRANFIELD UNIVERSITY

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THE ASSESSMENT OF THE RELATIONSHIP  
BETWEEN  
INFORMATION TECHNOLOGY (IT)  
AND  
AIRPORT PERFORMANCE

SCHOOL OF ENGINEERING  
AIR TRANSPORT DEPARTMENT

PhD  
Academic Year: 2015

Supervisors: Dr Romano Pagliari / Dr Zheng Lei

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the degree of Doctor of Philosophy

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## **ABSTRACT**

The evolution of the airport business is demonstrated by airports that are adopting new business strategies and commercial models, which allow them to be, for example, service providers instead of real-estate managers, with the focus on cost reduction and increasing non-aeronautical (commercial) revenues. Information technology (IT) can be used by airports to achieve their business goals, such as enhancing performance by delivering cost reductions and generating additional revenue streams.

Airports operate in an increasingly competitive and dynamic market, with the aim of attracting a larger share of hub traffic from neighbouring airports. Therefore, financial and operational performance will be key elements for airlines when choosing a new airport destination.

The research shows that airports are more focused on passenger satisfaction, resulting in airport performance indicators that have the passenger at its operational core and performance targets (e.g. Airport Service Quality passenger satisfaction survey). IT plays an important role in increasing airport performance through the automation of processes such as the deployment of common-use check-in desks and self-service check-in kiosks. Studies of other industries have shown evidence that IT impacts firm performance, but there have been few studies related to the airport industry.

Thus, the aim of this research is to assess the relationship between IT and airport performance, and it proposes a conceptual framework to assess the relationship between IT and airport performance by drawing from studies in other industries.

Two methodologies were used in this research, the first one was the case study, and the second one was the online survey. The case studies consisted of 16 face-to-face interviews with senior staff representing two airports in Asia, one airport in Australia, and one airport in Europe. The case studies result show that there is a relationship between IT and airport performance.

The online survey collected responses from 154 airports in 70 countries, and the results show that there is relationship between IT and airport performance. The

statistical analyses of the online survey results demonstrate that of the four airport characteristics only two have a positive relationship IT culture (i.e. management preferences for Service Level Agreements (SLA), and competition intensity) and two have not shown a statistically significant relationship (i.e. ownership, and outsourcing). In addition, the results show that the overall passenger satisfaction dimension of the Airport Service Quality (ASQ) has a positive impact on airport performance.

The results specific to IT show that IT investment has no impact on airport performance. However, selected systems such as common infrastructure for check-in desks and kiosks (i.e. CUTE/CUSS), Airport Operations Database (AODB), Resource Management System (RMS), Flight Information Display System (FIDS), solutions for baggage management, and Airport Collaborative Decision Making (A-CDM) show a significant relationship with airport performance.

The implications of this research and the limitations of the proposed framework are discussed in the final chapter, as are recommendations for future research areas.

Keywords:

Airport characteristics, airport operations, airport technology, performance indicators, service quality, IT investment, IT culture, airport systems, surveys, case studies

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## LIST OF ACRONYMS

Acronyms	Description
A-CDM	Airport Collaborative Decision Making
ACI	Airports Council International
ACRP	Airport Cooperative Research Program
AMS	Airport Management System
AODB	Airport Operational Database
ASQ	Airport Service Quality
ATRS	Air Transport Research Society
BI	Business Intelligence
BRS	Baggage Reconciliation System
CDM	Collaborative Decision Making (a.k.a. A-CDM)
CEO	Chief Executive Officer
CFO	Chief Financial Officer
CIO	Chief Information Officer
COO	Chief Operations Officer
CUSS	Common Use Self-Service (Kiosks)
CUTE	Common Use Terminal Equipment
DEA	Data Envelopment Analysis
EBITDA	Earnings Before Interest, Taxes, Depreciation, and Amortisation
FAA	Federal Aviation Administration
FIDS	Flight Information Display System
IATA	International Air Transport Association

Acronyms	Description
ICAO	International Civil Aviation Organisation
ICT	Information and Communications Technology
IT	Information Technology
OECD	Organisation for Economic Co-operation and Development
RFID	Radio Frequency Identification
RMS	Resource Management System
ROI	Return on Investment
ROIC	Return on Invested Capital
SLA	Service Level Agreements
TFP	Total Factor Productivity
VFP	Variable Factor Productivity
WLU	Work Load Unit

# 1 INTRODUCTION

## 1.1 Background

Airport infrastructure development is still high on the agenda of most developing countries. The BRIC (Brazil, Russia, India, and China) countries have benefited from a high level of investment, or commitment of investments, in airport infrastructure, aimed to upgrade or improve the current infrastructure to cope with increased demand. According to CAPA's database of airport infrastructure investment projects there are approximately US\$385 billion of airport projects, and Asia Pacific has the largest share with US\$115 billion worth of projects. For example, China invests US\$45 billion on airport infrastructure development on a rolling basis (CAPA, 2014).

The lessons learnt from the recent economic downturn and the wave of airport infrastructure investments are changing the way in which airports are now managed. They have had to change their organisation to become more agile, capable of dealing with market changes, manage disruptions, and fight the competition. For most airports, the change entailed the adoption of new business models *“to specialize in the needs of specific clients and serve them cost-effectively; and to spread nationally and internationally – to achieve economies of scale and scope”* (de Neufville, 2003). Examples of these new models are airports that cater to low-cost airlines (Rome Ciampino, Italy); hub airports with non-stop operations (Atlanta, USA); and mostly cargo operations airport (Viracopos, Brazil; Memphis, USA).

Airport operators are also transforming themselves from being “landlords” (Gillen and Lall, 1997) to becoming service providers. This also means that airport operators are now taking control of the infrastructure; for example, check-in counters becoming a commonly shared facility as opposed to a single airline-dedicated area.

The air transport industry is one of the best examples of a *“global industry”* integrating the transport network of countries and operating under a common platform (ACI, 2008). The result of globalisation is the increase in competition

among airports. “Airports compete now more than at any time in the history of aviation” (ACI, 2006, p. 3) where they compete for new routes, new airlines and customers.

The globalisation of the airport industry can be seen by the number of infrastructure investors and multinational airport groups operating airports beyond their own countries; this is shown on Table 1 (Globalisation matrix of the airport industry). For airports, the impact of globalisation is that they now share common management practices and corporate governance. Thus, these airports are expected to enhance their competitiveness through standardisation of processes, technology and operations; a more business-focused approach to management and the benefits of economies of scale.

Investor / Airport Group (2016)	Country	Airport
AENA	UK	Luton
AviAlliance GmbH	Greece Germany Hungary	Athens Dusseldorf, Hamburg Budapest
Changi Airport Group	Brazil	Rio de Janeiro
Corporacion America	Argentina Armenia Brazil Italy Uruguay	Buenos Aires + 31 other airports Yerevan Brasilia Trapani Montevideo, Punta Del Este
Ferrovial	UK	London Heathrow, Aberdeen, Glasgow, Southampton
FRAPORT	China Germany Peru Turkey	Xian Frankfurt, Hannover Lima Antalya
IFM Investors	Australia UK	Perth, Melbourne, Queensland, Brisbane Manchester, Stansted, East Midlands, Bournemouth
Global Infrastructure Partners	UK	London Gatwick, Edinburgh
Macquarie Airports Group	Australia Belgium	Sydney Brussels

**Table 1. Globalisation matrix of the airport industry.**

The ownership structure models also drive competition amongst airports, because they will determine the business objectives of an airport. For example, revenue or extracting more shareholder value in the case of a privately owned airport. The ownership models range from government-owned and managed



(public utility management) models to corporatised to privatised models to public-private partnerships.

Regardless of the ownership model and competitive landscape, airports are expected to be managed effectively<sup>1</sup> and efficiently. Unlike airlines that can dispose of their physical assets; i.e., by retiring or leasing aircraft. While airports could close off redundant areas, saving on operating expenses, they are still lumbered with capital cost burdens of redundant assets. They are instead left with large sunk costs on an expanded infrastructure whose forecasted increased demand did not occur. Airports need permission to grow, which means that *“adding to airport capacity is notoriously difficult, slow and an expensive process”* (Forsyth, 2007, p. 47).

According to the ACI 2014 Airport Economics Report, it is widely believed that the growing importance of non-aeronautical revenues is reflected in the increased attractiveness of retail facilities at airports. However, the report also shows, since 2000, a decline in the percentage of non-aeronautical revenue as a percentage of total airport revenues. One possible explanation is attributed to the heightened security measures implemented after 9/11, resulting in new security charges, thus increasing the share of aeronautical revenues.

In 2013, non-aeronautical revenues contributed to 43.3% (ACI 2014 Airport Economics Report) of the industry's revenues, of which 4.5% are non-operating revenues (i.e. subsidies, grants, interest income, and other related non-operating revenues). From the industry's perspective, the source of 66% of non-aeronautical revenues are generated by retail concessions contributing 28%, followed by car parking operations with 20% and property rental income with 18%.

The importance of non-aeronautical revenues becomes very apparent during periods of economic downturn because they tend to generate higher profit margins, as well as the possibility of diversifying them. This provides airports with

---

<sup>1</sup> According to Melville et al. (2004, p.5) effectiveness is defined as the achievement of the company's goals by taking into account its competitive environment.

a way to soften the impact of revenue losses caused by a reduction in passenger traffic. The healthy commercial operation of an airport, which generates substantial profits, not only increases its credit ratings, but facilitates it getting lower cost borrowing from capital markets.

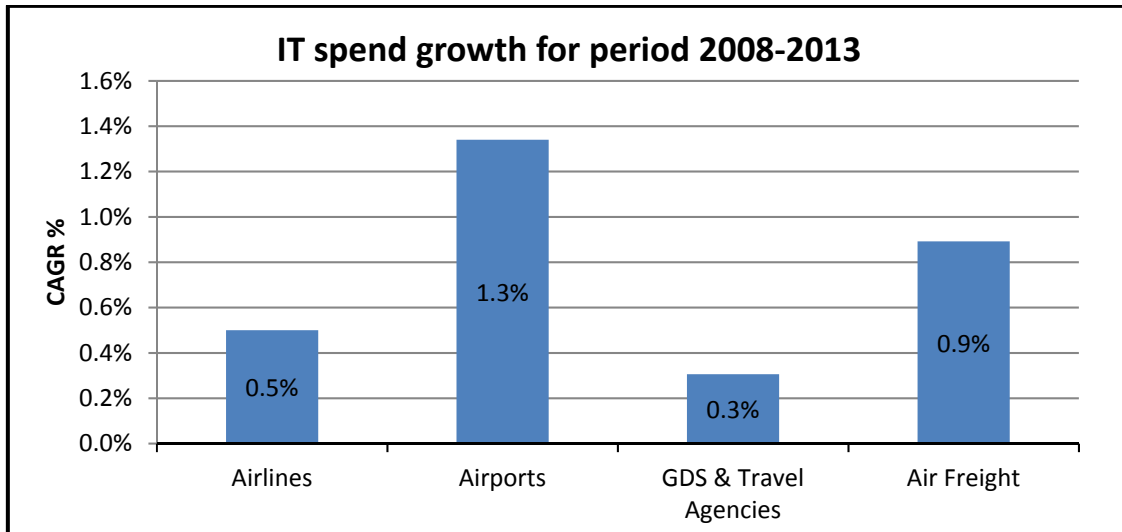
The increased profitability of an airport also makes it more attractive to investors during the privatisation period, or when an airport requires capital for infrastructure development projects.

To increase non-aeronautical revenues, the airport industry has adopted new business strategies of commercialisation and business diversification, thus limiting its dependency on government subsidies; and the reliance on aeronautical revenues to be able to invest on infrastructure improvement and development.

Having clear business objectives and running airports as self-sustaining businesses are key elements to their survival and growth. Equally important should be their ability to measure and compare their performance in this growing and competitive market (Graham, 2005).

Airports are usually physically constrained, and along with high infrastructure costs and long planning cycles, there is very little they can do about these conditions. Therefore, the most economical and successful way of expanding capacity and improving overall operating efficiencies, is to engineer flexibility into an airport's infrastructure with the deployment of Information Technology (IT). Technological innovation will not only bring an airport and its tenants cost reductions, but it will also generate new business opportunities and new sources of income.

According to a study commissioned by SITA to Gartner on the Air Transport IT spend, the airport industry is expected to spend approximately US\$2.5 billion by 2013 as shown in Figure 1. Airports have also shown to have the highest growth in IT spend, compared with the other sectors of the Air Transport industry (Gartner, 2010).



**Figure 1. Gartner’s forecast of the IT spend in the air transport industry from 2008-2013.**

High in short-term priorities of airports are investments in applications to increase operational efficiency (67% of airports) and reduce costs (63% of airports). These priorities can be explained as a result of the financial pressures the airport industry was suffering in 2008. However, airports are also investing in technology to “enable new market offerings” (SITA Airport IT Trends, 2009) and to create new revenue streams. As the economic situation improves, the priorities of airports priorities have also changed; their main priority is to improve customer service (63%), whilst cost reduction is in third place (46%), just behind improving safety and security (53%) (SITA Airport IT Trends 2011).

There are airports known for commercialising their IT infrastructure to generate new revenue streams; e.g. Dusseldorf Airport and Toronto International Airport. They are able to do this because of the standardisation and consolidation of the technology used across the respective airports. In addition, both airports have visibility on all cost items, thus enabling them to re-sell these technologies, such as IP telephony to their tenants.

The consolidation and standardisation of technologies are key strategic directions of an airport’s IT strategy, particularly for brownfield airports (airports with an

existing infrastructure), because of their procurement policies, which tend to buy standalone<sup>2</sup> applications with little or no integration with other airport systems.

Airport owners, operators, investors, and stakeholders will be keen to measure an airport's financial and operational performance as a way to guarantee their investment and to measure the competitiveness of the airport's business. The results of the IT trends survey of 2010, which had 128 respondents representing 220 airports, indicated that 63% of these respondents represented the top 100 airports (Airline Business, 2009) in passenger traffic. These top 100 airports also had the full spectrum of ownership structures, with the majority being publicly owned airports (66%), followed by mixed and/or corporatised airports (20%) and 14% of privately owned airports.

In summary, regardless of their ownership structure, airports are adopting new business models and focusing on increasing their non-aeronautical revenues, increasing their operational efficiency, and reducing their costs. These provide the ideal background for the deployment of IT to reduce an airport's costs and to increase its operational efficiency, thereby establishing a relationship between deployment and use of IT, and how an airport performs.

## **1.2 Definition of the problem**

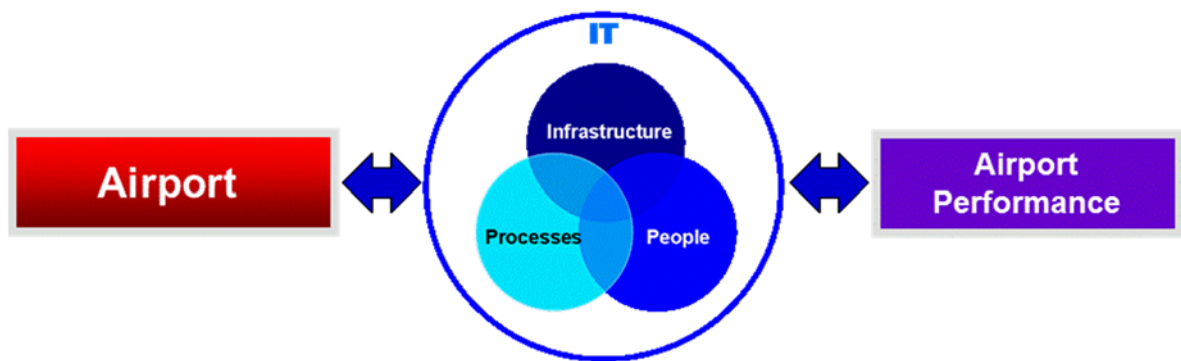
Within the airport industry, one of the most important value propositions of an IT solution is the efficiency gains resulting in cost reductions, which in the current economic context is one of the main business objectives of an airport. However, cost-reduction initiatives are not always the primary objectives of an airport. For example, there are airports that invest in IT because they want to be seen as innovators, such as Hong Kong International Airport, which is currently funding the deployment of RFID baggage tags at its own cost, as well as the introduction of biometric identification for arrival passengers (HKIA, 2005, p. 24).

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<sup>2</sup> Standalone applications mean applications that do not require integration with other systems, i.e., that they can operate independently. According to the Oxford Dictionary, "stand-alone or standalone" is defined as "*of computer hardware or software able to operate independently of other hardware or software*".

IT has been used to deliver on some of the corporate objectives of airports, such as reducing costs and increasing operational efficiency. SITA's Airport IT Trends survey confirms this view, where 67% of the surveyed airports plan to invest in applications to *“improve organisational productivity/efficiency, and 63% will be increasing investments in solutions that lower enterprise costs”*. (SITA Airport IT Trends<sup>3</sup>, 2009, p. 2).

Other than cost reductions, this research aims to identify other benefits of IT and to establish the relationship between IT and airport performance. Figure 2 describes how to establish the relationship between airport, IT and airport performance. Airports have different characteristics (e.g. size, ownership structures and business objectives) that may impact on how an airport deploys IT to improve airport performance.



**Figure 2. Establishing the relationship between IT and airport performance.**

IT as shown in the diagram above, is the combination of infrastructure (hardware and software) and people (skills) to operate the new systems, as well as processes. Because of the automation of activities, certain processes become redundant (e.g. writing manual reports or exchange of information) resulting in more efficient operations. For example, the introduction of common-use check-in facilities can reduce the number of counters by approximately 50%.

For example, at Sao Paulo (Guarulhos) International Airport, without common-use check-in, an additional 108 counters would have been required as result of

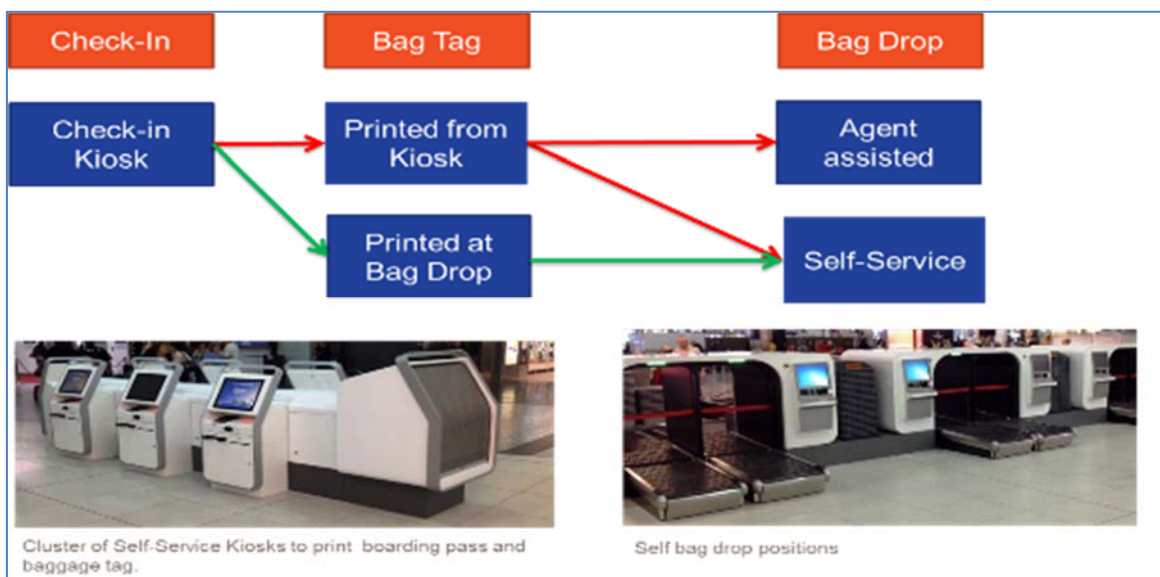
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<sup>3</sup> SITA Airport IT Trends Survey is an annual joint publication of ACI, SITA and Airline Business.

passenger traffic growth, which represents a 75% savings in the physical number of counters. Moreover, with 10 common-use self-service kiosks and six baggage drop counters, airlines can handle approximately 300 passengers per hour compared to 108-120 passengers per hour handled by agents at six counters.

The introduction of technology such as common-use check-in or common-use self-service kiosks is not sufficient, because they require a change in the process. When handling passengers on self-service kiosks for example, the process presently requires that passengers who check in at the kiosk receive their boarding pass from the machine. If they have baggage to be processed, they will then proceed to the counter to receive a baggage tag. Therefore, from a process perspective, the agent will no longer issue the boarding pass at the counter, but simply issue and place the baggage tag, thus speeding up the passenger handling.

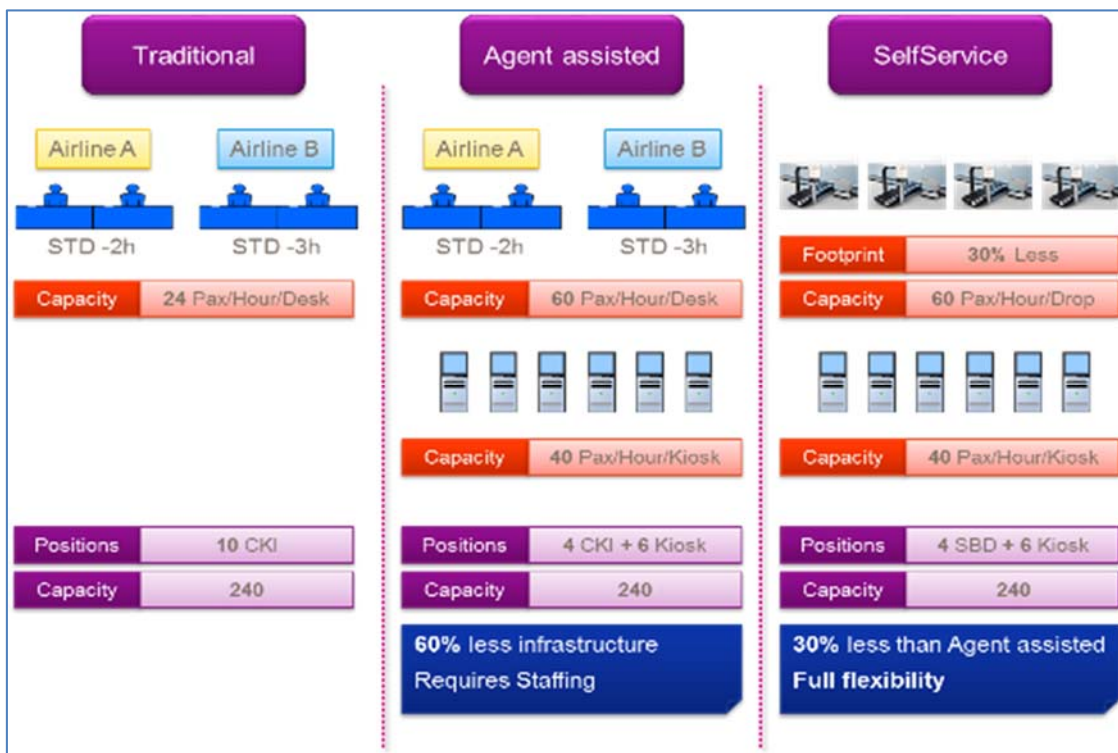
The alternative is an integrated check-in and baggage-drop self-service (i.e. without agent assistance) that is shown in Figure 3. In this alternative scenario, the passenger prints the baggage tag at the kiosk or at the bag-drop equipment, then the passenger tags the baggage and drops the tagged baggage at a specified bag-drop location.



**Figure 3. Self-service check-in and bag drop.**

Source: Author.

The introduction of self-service technology improves airport performance, and technology vendors are able to demonstrate these improvements. According to SITA, the average processing time of bags is less than 25 seconds using the self-service bag-drop solution at an Australian airport. The self-service baggage in addition to reducing the processing time can also reduce infrastructure requirements, which means an airport is able to handle more passengers in a constrained terminal, as shown in Figure 4.



**Figure 4. Comparison of the operational benefits between traditional versus self-service check-in.**

Source: SITA.

The introduction of self-service technology enables airports to process passengers at a higher rate, because passengers have an alternative to the agent-assisted check-in process. This optimisation of the process through technology has an impact on airport performance.

Self-service is just one example of an IT solution adopted by airports to improve their operational performance. According to SITA's 2014 Airport IT Trends Survey, an annual report published by SITA in conjunction with ACI and Airline

Business, airports have identified three areas (i.e. passenger processing, security and airport operations) as their top IT investment priorities. The survey also shows that the industry-planned spend on IT is US\$6.8 billion or 5.07% of total revenue.

The IT spend of 5.07% by airports is high compared with Gartner's cross-industry average of 3.3% spend of revenue, where the highest spend is 6.7% in software publishing and internet services, and 6.3% in banking and financial services. According to a report by Caldo et al. (2014), banks with high IT- effectiveness also had a high profit margins, and the study shows that the areas in automation and analytics/big data are correlated to profit margins. This report also shows that banks with strong IT management capabilities (i.e. strict cost control and standardisation of IT infrastructure) show a strong correlation in reducing the spend on day-to-day operations.

However, despite the relatively high IT spend by airports, and unlike other industries (e.g. banking) in which the subject of IT and firm performance has been widely researched, the airport industry lacks this kind of research.

The impact of IT on airport operational performance can be demonstrated by technology vendors. However, it is not evident whether airports are investing in IT only to improve operations or whether investments are also driven by the strategic needs of an airport. For example, to support an airport's growth ambitions or gain a competitive advantage. But most importantly, whether these investments have an impact on airport performance (i.e. financial and operational).

Furthermore, in the literature reviewed, the author found few studies relating to IT and airport performance, with the majority of them focusing on specific applications or systems and their impact on airport performance.

Therefore, the gap in the literature regarding IT and airport performance is the main reason for undertaking this research.



### **1.3 Aims and objectives of the research**

---

This section defines the aims and objectives of this research, which later on will enable the evaluation of the chosen methodology and whether it has achieved successful results.

The aim of this research project is defined as follows:

#### **To assess the relationship between IT and airport performance**

The definition of “aim” is still broad, and to demonstrate the direction of this research, several objectives have been set and are described as follows.

Objectives:

- To determine IT culture and its relationship to airport performance through understanding of the role, importance and benefits of IT.
- To determine the airport IT characteristics that have an association with airport IT culture
- To determine if airport IT characteristics have an association with airport performance.
- To determine the relationship between IT investment and airport performance.
- To determine from selected IT Systems the ones that have an association with airport performance.

### **1.4 Potential contribution to the body of knowledge**

This research aims to contribute to the body of knowledge by providing an insight into the relationship between IT and airport performance, which to date has not been a widely researched subject.

The potential contribution to the body of knowledge is in three areas: research, method and trending issues.

**Research area:** as described in Section 1.2, there is a gap in the literature relating to IT and airport performance. The research area focuses on understanding the IT culture of an airport; that is, to understand the role of IT, its importance to airports and its benefits. This understanding sets the premise of

the relationship between IT and airport performance, which is to determine whether IT matters and if it matters to assess the impact on airport performance. Building upon on research from other industries on IT investment and firm performance, the research investigates the impact that investment and selected airport systems have on airport performance.

**Method:** In the literature reviewed by the author, there were few studies in the area that could serve as a model. Therefore, the method deployed in this research was adapted from the IT industry to test the hypotheses. The method also adapted a strategy formulation framework to determine an airport's IT characteristics.

**Airport trending issues:** To address the current trending issue of improving passenger processing, and in the context of this research, how technology can help airports to address it.

The other contribution of this research is for IT practitioners in the airport industry, as well as for airport operators, to understand the relationship between IT, IT investment and its impact on airport performance.

This research also provides a view on different guidelines and references regarding airport performance indicators.

The airport industry, like other industries, is becoming increasingly international and global, especially from an investment perspective, where institutional investors and airport operators are expanding their reach beyond their own geographical area of origin. For example, Australian Investment Fund (AIX) and Macquarie Airport Group, both Australian companies, have invested in European airports. Other examples of investments by airports outside their home base are Changi International Airport from Singapore, and ACSA (South Africa) both invested in airports in Brazil, respectively RIO Galeao airport and GRU airport.

The globalisation of the airport industry highlights the need for a study that will assist them to make sound IT investment decisions and to understand the impact they will have on airport performance. Therefore, this research aims to benefit the main stakeholders of the airport value chain (see diagram below).



- Airport Investment: IFM Investors, Ferrovial, Global Infrastructure Partners
- Airport Engineering & Construction: Arup / Parsons / Bechtel
- Airport Management: Changi Airport Group / FRAPORT
- IT Suppliers and IT service providers: SITA, Amadeus IT Group, Rockwell Collins, and Leidos

## 1.5 Outline of this thesis

Chapter 2 provides the theoretical viewpoint, an understanding of the current considerations in the areas of key airport characteristics (i.e. ownership, management preferences, resources and competitive environment), Information Technology (IT) and airport performance.

In Chapter 3, the research questions resulted from the literature review and their respective hypotheses. In this chapter, the main areas of the research discussed are: IT culture and its impact on airport performance; the airport characteristics (ownership, management preferences in terms using Service Level Agreements (SLA), resources, and the competitive environment), the dimensions of Airport Service Quality areas that impact airport performance, the IT investment impact on airport performance and, finally, the impact of selected systems on airport performance.

Chapter 4 introduces the research strategy and the choice of methodology (i.e. online survey). It also describes the different steps taken to develop the online survey methodology: (1) questionnaire design, (2) questionnaire validation, (3) population, and (4) data collection.

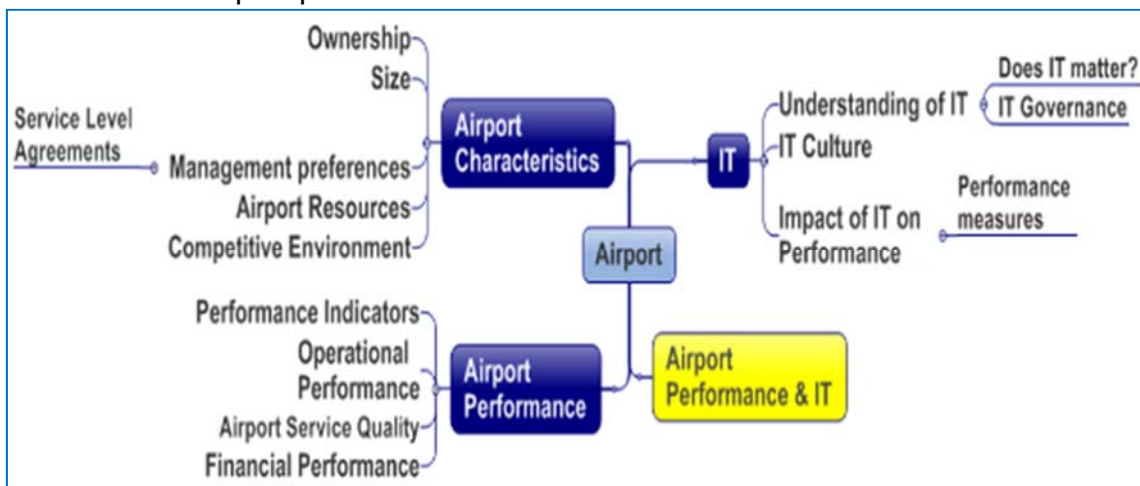
Chapter 5 discusses the findings of four airport case studies (i.e. case studies as result of the interviews with one airport in Southeast Asia, Northeast Asia, Australia, and Europe), and the results of the online survey.

In Chapter 6, a summary of the findings is presented in relation to the objectives of the research, and the implications of the findings are discussed in four areas (i.e. the role of IT, benchmarking, IT investments, and technology). The research shows, despite limitations, the achievement of the aim and the objectives of the research. In addition, the research finishes with a list of recommendations for future research.

## 2 LITERATURE REVIEW

This chapter provides the theoretical foundation of the thesis through a review of literature relevant to this research. The search strategy of the literature review is shown in Figure 5, which has four themes:

1. Airport characteristics
2. Airport performance
3. Information Technology (IT)
4. IT and airport performance



**Figure 5. Search strategy mind map to narrow the search into specific themes.**

The literature review begins by examining an airport, mainly its characteristics, and how these impact performance. The second theme is airport performance, which seeks to determine the dimensions of airport performance in areas such as the type of performance indicators and the measurement or benchmarking of performance, both at operational and financial levels. Information Technology (IT) is the third theme of the literature review, and describes the impact of IT and business performance, which provides an insight into how other industries measure the impact of IT on business performance. The last theme, which is also the focus of this thesis, is the review of literature relating to the impact of IT on airport performance.

### 2.1 Airport characteristics

“Airports are a critical part of the economy of the state within which they are located. They serve as engines of growth for their local, regional and national economies” (ACI Policy, 2009). As an integral part of the economy and key

economic driver, airports require investments to expand, because a constrained infrastructure will be detrimental to the region's or country's growth (BAA, 2011). In addition, with a scarcity of funds for infrastructure development, governments realised that through privatisation of their airports they found a new source of funds to finance their infrastructure upgrades, as well as to increase their operational efficiency (Hooper, 2002).

IATA (International Air Transport Association) expects passenger numbers to reach 3.91 billion by 2017, which will put tremendous pressure on airports and their infrastructures. Airports will have to cope with this increased passenger growth in a constrained environment, and still provide a high level of service to remain competitive. The need to expand through either greenfield airports or expanded terminals require access to capital or ways to finance the undertaking of such activities. In the case of capital markets, it is expected that they assess the risk of these investments, as well as the operational sustainability of an airport.

Large commercial airports or airports groups appear to be financially strong as an effect stemming from characteristics of the airports, such as size and approach to financial management (Airport Systems Development, 1984, p.144).

Conversely, a number of studies indicate that airport characteristics, such as size (Francis, Fry, Humphreys, 2001; Oum, Yu, 2004; Assaf, 2009), may explain the contribution to the performance of an airport.

Size does matter and large airports generally outperform smaller airports. The impact on performance as result of size can be explained by the economies of scale enjoyed by large airports (Graham, 2005). However, size alone was not the only characteristic to contribute to airport performance, but when combined with other characteristics, such as facilities, physical infrastructure and location, they contributed in the difference of performance between large and small airports (Assaf, 2009). On the other hand, *Lin et al. (2006)* argue that size had not had a significant impact on airport performance, although location and the presence of a hub airport appeared to be relevant to airport performance.

The type of passenger traffic, domestic versus international traffic, may also have an impact on airport performance, particularly in terms of revenues and costs, with international passengers expected to generate more revenues (Graham, 2005). Domestic passengers, however, were expected to reduce costs, as it requires less in terms of infrastructure and less revenue due to lower spending (Mackenzie-Williams, 2005).

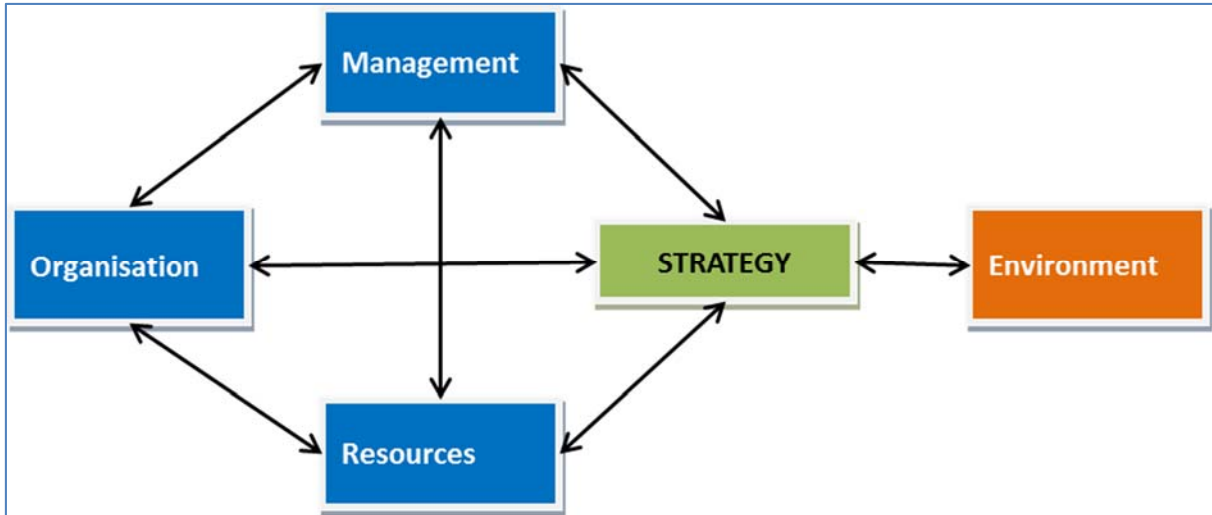
In a study carried out by Park (2003)<sup>4</sup>, he assessed the competitiveness of airports based on key characteristics, which he named as “*factors*”: Resources (Spatial and Facility), Environment (Demand) and Management (Service and Managerial). The findings of Park’s study indicated that traffic demand was the most important factor, followed by service. Other factors showed to be of “moderate importance”.

Therefore, for the purposes of this research, the characteristics – airport size, traffic mix and demand – have not been considered as factors to determine airport performance, because they are outside the control of the airport. For example, size reflects the presence of economies of scale; traffic mix is split between international and domestic passenger volume; and demand reflects the network density of the airport to generate demand (Park, 2003).

However, there are other characteristics that would also have an impact on airport performance. To determine the other characteristics, a framework was used to determine the airport characteristics that would impact the performance of an airport. The Diamond-E Framework was originally proposed by Fry and Killing (2000), and is a framework used by companies to formulate their strategy by analysing internal (i.e. management preferences, organisation, and resources) and external (i.e. the environment or marketplace a company operates) factors, as shown in Figure 6.

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<sup>4</sup> Park’s Five core factors: *Spatial* (level of development of the region where the airport is located), *Facility* (level of facilities of the airport), *Demand* (traffic demand), *Service* (service and user charge levels), and *Managerial* (economics of the airports, such as costs, productivity and revenue structure).



**Figure 6. Diamond-E framework.**

The original framework is a simple model that consists of business capabilities (i.e. blue boxes of Figure 6), strategy and external environment. The analysis using the framework is done in two steps: (1) to determine the strategic objective of an airport by converting the aim of this research; and (2) to analyse the internal capabilities of an airport and the external environment in which the airport operates.

The aim of this research was to determine the relationship between technology and airport performance, and by applying the framework, the research objective was converted into a strategic objective (i.e. the use of technology to enhance airport performance), and its four strategy elements would be:

- Goals: use of technology to enhance airport performance
- Differentiation: using technology and services to enhance competitiveness
- Market: services provided by airports to facilitate passenger, baggage, and aircraft operations
- Business system: how products and services are delivered to help the airport distinguish against the competition through better and enhanced experience and operational efficiency of the airport to enable their airline customers and other stakeholders to deliver their services

The strategic objectives of the airport as described above were considered when creating the questionnaire. However, for the airport to achieve its strategic



objectives it must balance the airport's internal capabilities and the pressures from the external environment (i.e. the market competitiveness).

The internal capabilities are best described as:

- Organisation: ownership structures that will determine and influence the strategic objectives of an airport because "different owners will have specific goals to achieve and different incentives to achieve them (Oum et al., 2006)
- Management: it reflects an airport's preferences for governance, policies and procedures that is it reflects the airport's culture such as preferences for adopting service level agreements to measure performance, as well as the IT culture of the airport (i.e. clear definition of the role, importance and benefits IT brings to the airport)
- Resources: refers to resources available to the firm to deliver its products or services

And the last element of the framework is the external environment or the market competitiveness, and the airports operating in a competitive environment are more efficient, as demonstrated by Chi-Lok and Zhang (2009) in their study of impact of competition and productivity of Chinese airports.

The adapted Diamond-E framework was an important tool to determine the key airport characteristics relevant in this research, to determine the relationship between IT and airport performance. These four key characteristics that resulted from the framework are:

- Airport ownership structures
- Management preferences
- Resources
- Competitive environment

The following chapters examine the literature of academic papers related to these characteristics and their relevance to this research.

### **2.1.1 Airport ownership structures**

The type of airport ownership is one characteristic that is worth considering when researching performance, because it can affect many areas of an airport's operations; for example, safety. Bruijne et al. (2005) found that the safety regulatory system of an airport under public ownership is less robust than it is under private control. Changes in the ownership landscape is also creating a more competitive environment (Barret, 2000), which in turn is changing the role of airport management in order to remain competitive and to increase an airport's attractiveness to airlines and passengers.

In terms of the impact on performance or efficiency of an airport, as a result of the different ownership structures, Oum et al. carried out three studies from 2002 to 2008. In the 2002 study, they compared the efficiency of 50 airports using a Total Factor Productivity (TFP), which measures "total output produced by a unit of aggregate input". The results of the study indicated that the "airport's ownership structure does not appear to have any statistically significant effect on its productivity".

However, Oum, Adler and Yu in their 2006 study focused on the impact of different ownership structures on airport performance, which showed different results from their earlier study. For this study, the Variable Factor Productivity (VFP – "the ratio of total aggregate output over aggregate variable input") was the model used to measure airport performance.

The study classified airports in six ownership structures: public, mixed public majority, mixed private majority, public with management contract (i.e. long-term lease), public with multi-airport management, and private. The study showed evidence that public airports are more efficient than airports with mixed public majority ownership. The profitability of an airport is also likely to be influenced by the airport ownership structure, and the study showed that private or mixed private majority had higher profit margins compared with other airports. The study also showed that airports with mixed private majority had, as a result of their business diversification, a higher percentage of their revenues generated from non-aeronautical activities.

In 2008, Oum, Yan and Yu presented the results of another study using a Stochastic Frontier Analysis to measure an airport's cost efficiency in relation to different airport ownership structures. Unlike in the 2006 study, these structures were categorised in a different way: private majority (mixed majority that includes 100% private airports), authority (public with long-term lease, but contracted to an independent management authority), public corporation (100% owned/managed by government), government branch (government ownership including US city-owned airports), multi-level government (ownership by multiple governments), and US port authority.

Airports with private majority, public corporations, and independent airport authorities showed themselves to be more efficient than those airports with mixed forms of public ownerships (i.e. government branch, multi-level or US port authority). The study shows the cost efficiency of different ownership structures, but it does not provide an explanation as to why a particular form of ownership affects an airport's cost efficiency. Gillen (2011) shows similar findings, in that "cost efficiency might differ among governance structures only that it apparently does". He concludes that regardless of the ownership, airports are subject to dynamic market forces that determine their economic costs and benefits, which will change according to the ownership structure put in place. However, efficiency has been measured against a static productive efficiency, therefore not presenting a more accurate measurement of airport performance.

Vasigh, Erfani and Sherman (2014) also conclude that airport productivity and efficiency depend on market forces, the regulatory and competitive environment in which they operate. The assessment of airport productivity and efficiency should be evaluated against these conditions (i.e. market and competition), instead of ownership structure.

### **2.1.2 Management preferences**

This airport characteristic should reflect the management preferences with regards to governance, policies and procedures. The changes in ownership structures also reflect the changes in strategic orientation of airports, with focus on commercial orientation and operational efficiency (Carney and Mew, 2003)

aimed at improving quality. In case of this research the management preference is related to the adoption of Service Level Agreements (SLA) and its relationship to airport performance.

The SLA can be defined as a commitment by two entities, that is the airport and its stakeholders (e.g. airlines, ground handling companies, and service providers) to meet agreed performance targets during the delivery of a service such as passenger check-in (ICAO Airport Economics Manual, 2013, pg. App 2-1). In addition to be used to ensure performance targets are met, the failure in delivering on services can have a reputational impact to airports, which can be exemplified by the statement from the ICAO Airport Economics Manual (2013, pg. App 2-1): *“An airport/airline(s) SLA is founded on the concept that airports and airlines are partners in serving the same customer — the airline passenger. The passenger experiences a joint airport/airline product that influences his or her opinion of the total travel experience. Dissatisfaction with any aspect of the airport experience may reflect unfavourably on the airport, the airline, or both, since the passenger is often unaware of the actual provider of a given service at an airport.”* An example of such failure of service is the failure of baggage handling systems on the opening day of Heathrow Terminal 5 and the “damage done to the reputations of BA and BAA will take a lot longer to repair than the minor faults that emerged back in March 2008.” (Brady and Davies, 2010).

Airports are also focusing on delivering a better airport experience to their passengers, and investing in technologies aimed at improving passenger processing (SITA Airport IT Trends, 2014). Therefore, in order that airports can deliver a better quality of services, which are aimed at improving or enhancing the passenger experience, they are adopting the notion of Service Level Agreements (SLA). This will ensure the quality of these services and provide the capability to measure how these services are delivered.

From an industry’s perspective, both ICAO and ACI have published guidelines addressing the implementation and utilisation of SLA. For example, ICAO Airports Economic Manual (Appendix 2), and the ACI World Best Practices Guidelines: Airport Service Level Agreements Framework (2014), which provides

a guidance principle to airports to define service levels to assist the airport to ensure they can provide the adequate infrastructure for airlines to deliver their services at the agreed performance level or SLA.

In a joint-collaboration between ACI World and IATA to update IATA's Airport Development Reference Manual (ADRM) a reference tool for airport planning that foster best practices through dissemination of standards and airport design. One example, is the Level of Service (LoS) framework<sup>5</sup> to ensure traffic demand, processing time and quality of service are taken into account during the definition of airport service levels. For example, the manual recommends that the optimum LoS, the waiting area per passenger for check-in is between 1.6m<sup>2</sup> - 1.8m<sup>2</sup>, and the processing waiting time for economy passengers is 10-20 minutes and between 3-5 minutes for business class passengers. Other examples of recommended Level of Services standards are waiting time at check-in, to drop bag, at immigration, at security checkpoints and transfer waiting times.

ACI's vision of the framework is to enable airport owners, managers and stakeholders to monitor airport performance by setting service levels throughout the passenger journey. And for these reasons, the management preferences for the utilisation of Service Level Agreements is one of the airport characteristics to be considered.

### **2.1.3 Airport resources**

The availability of resources, either in terms of physical infrastructure or in terms of human resources, to deliver on an airport's objectives are important internal capabilities. The availability of these resources are costly to airports and, in some cases, they would rely on outsourcing, which may significantly reduce the cost of labour (Pels et al., 2003).

In 2001, BAA PLC in a response to the UK Civil Aviation Authority (CAA) consultation paper on "competitive provision of infrastructure and services within airports" set out its policy on outsourcing, which stated that it is always an option

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<sup>5</sup> ADRM defines three level of services: overdesign, optimum, and suboptimum.

if it is believed that there are cost and efficiency savings without compromising quality of service.

Airports are also considering the outsourcing of terminal facilities management, traditionally an activity performed by an airport's organisation. One example is Beijing Capital Airport Terminal 3, where management was outsourced in 2008 to CB Richard Ellis (CBRE), an international commercial property consultancy (Passenger Terminal Today, 2008). This is expected to generate operating cost savings of approximately 25% as a result of the restructuring and re-training of the staff.

Other areas that are commonly outsourced are IT and security. In the United States, airport security is carried out by TSA (Transportation Security Administration) as result of 9/11, but in 2012, under the FAA Modernization and Reform Act (FAA, 2012), passed a new law that gives airports the flexibility to use private security companies to carry out the security screening.

The outsourcing of IT is rather common and ranges from outsourcing of data centres (Frankfurt Airport) to full IT outsourcing (Dusseldorf International Airport and New Delhi International Airport).

Resources, in the context of airport characteristics, refers to the use of outsourcing as a cost-effective solution to secure resources to deliver services.

#### **2.1.4 Competitive environment**

There are divergent views about the competitive environment of an airport, with IATA (2007) considering airports as natural monopolies. However, ICAO in its working paper on Airport Competition (2013) argues, *"in an increasingly liberalized market, airports of all sizes are exposed to a variety of competitive constraints. With increasing freedom of choice for passengers and airlines, airports have to more actively provide the right product at the right price to retain their customers"*.

In the same year, (2013) IATA published its report on Airport Competition, in which it recognises that competition is as important for airports as it was for the

airlines; it brings innovation, cost reductions and delivers major benefits to consumers. IATA argues that some airports do compete, but cannot generalise that all airports compete with each other, and robust economic regulation is required. However, economic regulation can perpetuate the conflict between airports and airlines (Gillen, 2011).

However, as Jimenez et al. (2013) summarised, it is commonly accepted that airports compete in two ways: (1) when there is an overlap of the catchment areas, and (2) when they compete as an alternative transfer hub. They have also identified other areas of competition between airports:

The airport as destination (inbound traffic): This type of competition tend to apply to large tourist areas (Tretheway and Kincaid, 2010). But airports are now aiming to become more attractive by making the airport a destination. One example is the recent announcement of the construction of Jewel Changi in Singapore, a new terminal that will have a waterfall in the middle of the terminal, 5 storeys above ground and five storeys below ground that will integrate airport operations, retail and leisure.

Expansion and funds: Airports compete for additional funds and/or for approval to expand their infrastructure. London Heathrow and Gatwick airports are a good example of this type of competition, with both competing for the approval to build a new runway.

Global competition: Airports are now competing with other regions through acquisitions or contract management. To illustrate this type of competition, Airports Company of South Africa won, as part of a consortium with Invepar, the concession for Sao Paulo International Airport (GRU) in Brazil; Singapore Changi Airport won, as part of a consortium, the concession for Rio de Janeiro International Airport in Brazil, and Vienna Airport has shares in Malta Airport.

The competitive environment of an airport is expected to have an impact on airport performance and long-term sustainability, and according to the European Union Competition Policy Brief (2014), “only the most inefficient airports will close down”.

## **2.2 Airport performance**

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The evolution of the airport business from a provider of infrastructure (i.e. terminal facilities and runways) to a service provider has also created a need to measure airport performance. Airport performance is being defined as a systematic and iterative approach to ensure that an airport's objectives are consistently met by focusing on key areas: safety and security, service quality, productivity/efficiency, financial, and environmental.

The need to measure airport performance has been receiving more attention from airport operators, airlines, governments, industry analysts, and academics. And the attention has been on comparing performances against other airports (benchmarking<sup>6</sup>), which in turn would help them to improve an airport's performance.

Since the aim of this research is to establish the impact of IT on airport performance, it is necessary to describe what is used to measure performance and how it is measured. This section has been structured in two parts: (1) review of performance indicators used by airports; and (2) review of the different methodologies used in the industry to measure airport performance.

### **2.2.1 Airport performance indicators**

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The airport industry is not new to the concept of measuring performance, and the commonly used indicators are financial ratios or traffic growth (operational performance). The sole use of profit or traffic growth as performance indicators are inadequate, because the airport industry does not compete in a perfectly competitive market where profitability can be equated to optimal performance. In fact, direct competition between airports is limited due to regulatory, geographical, political and economic constraints (Gillen et al., 1997).

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<sup>6</sup> Adler et al. (2009) defines *“benchmarking as the systematic process of measuring and comparing an organisation's performance against best practice in the industry gain information to help the organisation take action to improve its performance.”*



The airport industry can also operate in either a monopolistic or semi-monopolistic position, and may abuse this situation by charging their customers higher fees or by wastefully using resources. High profit levels cannot give any indication of the cost of resources being used to achieve such levels of profit. Also, in the case of airports owned by governments, it is not possible to ascertain how much of the resources are funded with public funds (Mackenzie-Williams, 2005). These indicators therefore cannot provide adequate information for benchmarking purposes.

Airport managers and airport operators are very aware of the financial and commercial implications of running an airport, therefore requiring the “*adoption of effective management and business techniques, including benchmarking*” (Graham, 2005). For airport managers and airport operators, performance measures will be an important management tool, as they define the relationship between an airport’s input and output; that is, the economic efficiency of an airport.

Equally important will be to determine what airports consider important to measure from a performance standpoint.

For airport planners, the importance of performance measures is to measure the relationship between input and output and how future developments or investments can affect overall performance. With the increased focus on airport privatisation (ACI, 2006), it can be expected that potential investors will analyse financial and operational performance of an airport when considering an airport as an investment opportunity.

Table 2 below shows traditional performance indicators used for airport performance benchmarking.

Traditional Performance Indicators	
Traffic Related Performance Measures	<ul style="list-style-type: none"> <li>• Annual terminal passengers or total annual traffic</li> <li>• Annual international passengers as a percentage of the total traffic</li> <li>• Annual cargo tons</li> <li>• Annual Work Load Units (WLU)</li> <li>• Air transport movements</li> <li>• Total passenger per movement</li> </ul>
Cost Performance Measures	<ul style="list-style-type: none"> <li>• Total costs per WLU</li> <li>• Total costs per movement</li> <li>• Operating cost per WLU</li> <li>• Capital cost per WLU</li> <li>• Staff cost per WLU</li> <li>• Capital costs as a percentage of total costs</li> <li>• Staff costs as a percentage of total costs</li> </ul>
Labour Productivity Measures	<ul style="list-style-type: none"> <li>• WLU per employee</li> <li>• Total revenue per employee</li> </ul>
Capital Productivity Measures	<ul style="list-style-type: none"> <li>• Total revenue per asset value</li> <li>• Asset value per employee</li> </ul>
Revenue Generation Performance Measures	<ul style="list-style-type: none"> <li>• Total revenue per WLU</li> <li>• Aeronautical revenue per WLU</li> <li>• Non-aeronautical revenue per WLU</li> <li>• Aeronautical revenue as a percentage of total revenue</li> <li>• Aeronautical revenue as a percentage of total operating costs</li> </ul>
Commercial & Profitability Performance Measures	<ul style="list-style-type: none"> <li>• Commercial revenue per passenger</li> <li>• Net profit</li> <li>• Net profit per WLU</li> <li>• EBITDA as a percentage of turnover</li> <li>• Revenue-expenditure ratio</li> <li>• Current ratio</li> <li>• Operating ratio</li> <li>• Operating profit as a percentage of turnover</li> </ul>

**Table 2. Traditional Performance Indicators.**

Source: Author adapted from Doganis (1992) and Graham (1999).

The Work Load Unit (WLU) is a commonly used performance indicator used in the airport industry. The WLU is an output measure that is defined as one passenger or 100kg of cargo (Doganis, 1992).

Traditional performance indicators have been the subject of critical reviews, because these traditional indicators have not taken into account the evolution of the airport business and that performance measures should provide relevant information to airport managers (Humphreys and Francis, 2000). Their view is

that some of the deficiencies of traditional performance indicators was that they measure “*what is easy to measure instead of what is important to measure*”.

However, easy as it may be, the main challenge is to obtain appropriate data in terms of both quality and availability. Financial information is often the most difficult data to be obtained, because airports tend to be more secretive about making their financial information available in the public domain. The other challenge is standardisation of financial data that is governed by accounting practices adopted by an airport, and this varies between airports in different countries.

It may be noted that there are other financial indicators not listed in Table 1 (e.g. equity ratios and the weighted average cost of capital (WACC)), because the indicators used are as good as the purpose of these indicators (i.e. what they are measuring) and in which context they are being used.

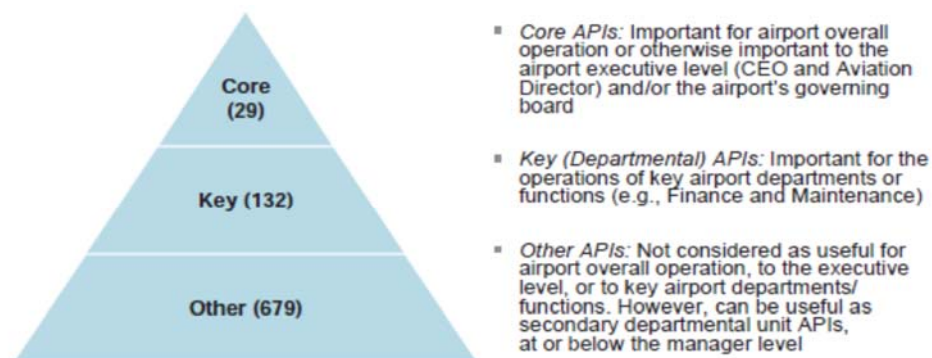
Therefore, the International Civil Aviation Organisation (ICAO) in their Airport Economics Manual (2013) proposes a framework by which to measure airport economic performance, which can be summarised in five steps:

1. Determine the performance areas: recommended areas are safety, quality of service, productivity and cost effectiveness. It is understood that other areas may be chosen according to the specific circumstances of an airport.
2. Define the performance objectives: they reflect goals that airport management wants to improve on; for example, increasing aircraft turnaround. ICAO recommends that in the case of prioritisation of objectives due to conflicts, safety-related objectives should take priority over other areas.
3. Determine the performance indicators: the indicators should reflect the purpose of the objective they are linked to. The number of indicators per objective should be carefully considered to take into account the potential challenges in data collection and analysis.
4. Set the performance targets for each indicator: ideally, set a unique value that will help to determine whether the objective has been achieved. An

important recommendation is that targets should relate to an airport's efforts to improve.

5. Performance assessment and reporting: an integral part of the performance assessment process is a set of recommendations to improve, close gaps or continue improvement. At this stage, an airport may consider setting a benchmarking that could be either internal (against itself over time) or external.

In addition to Traditional performance indicators, the Airport Cooperative Research Programme (ACRP) has published a guide, ACRP Report 19A: Resource Guide to Airport Performance Indicators, with more than 800 airport performance indicators, which are organised in three categories as shown in Figure 7.



**Figure 7. Categories of airport performance indicators**

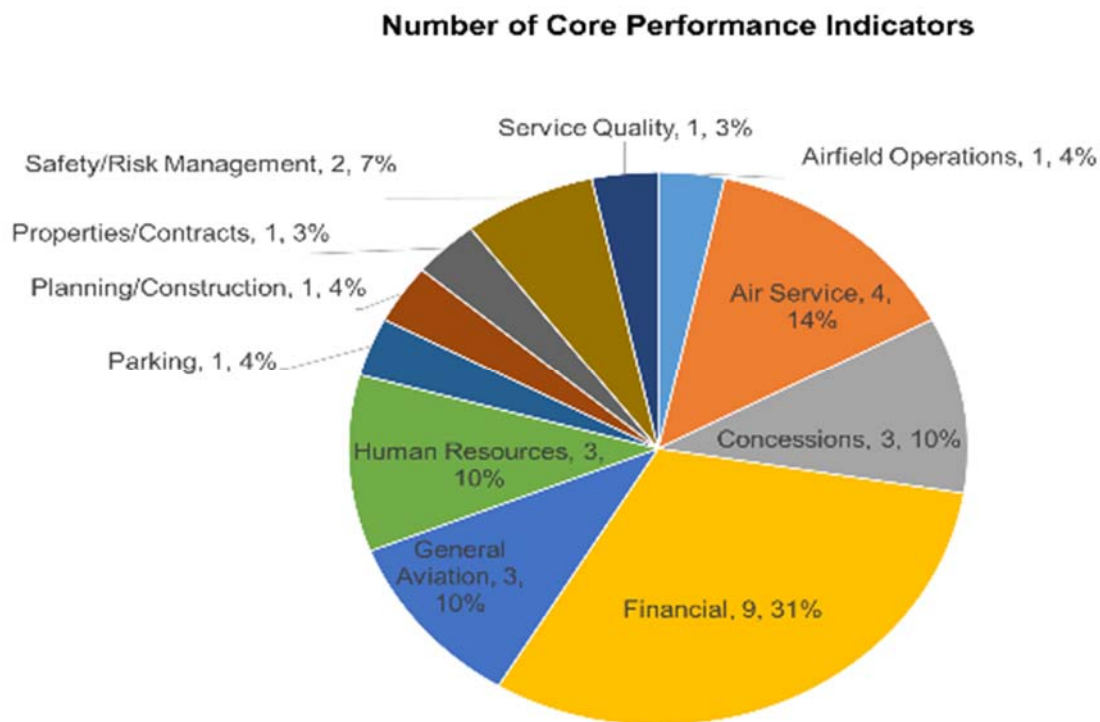
Source. ACRP 19A, p. 2

The ACRP guide provides a description of 29 core indicators and 132 key indicators classified under 23 functional areas, ranging from airfield operations to financial to service quality to terminal operations.

It would be expected that airport executives, target users of the core category, would be concerned about the financial performance of the airport, as well as areas that would have a significant impact on financial performance, such as

concession, general aviation<sup>7</sup> and car parking. This is demonstrated in the chart below in Figure 8, which shows that 52% of the indicators or 16 indicators out of 29 are to measure financial performance.

The other area of performance being monitored at the executive level is related to operations (Air Services<sup>8</sup>, Airfield Operations and Service Quality), representing 20% of the performance indicators.



**Figure 8. Description of the core categories and their respective number of performance indicators.**

Adapted by author based on ACRP 19A.

Information technology is one the functional areas used by ACRP, and the guide lists 21 indicators, none of which are in the core category and only two of which are in the key category, which means they are relevant to the operations of key airport departments or functions.

<sup>7</sup> General Aviation performance indicators focus on non-aeronautical revenues relating to sales of fuel, renting of facilities and commercial services provided by the airport.

<sup>8</sup> Air Services are indicators used to measure passenger volume, frequencies that will help airports to monitor capacity and operational requirements.

The majority of the IT indicators are used to measure availability of the IT systems or restore time in case of outages. These are particularly important measures if the systems are mission-critical, such as check-in systems, baggage handling or flight information displays systems that can create major disruptions in the event of a system outage. However, none of the 21 indicators are used to measure the impact of IT on airport performance.

Airports Council International (ACI)<sup>9</sup>, in pursuing one of its remits to develop standards and recommended practices, in 2012 published a Guide to Airport Performance Measures.

The guide follows ICAO recommendations by determining key performance areas, although in this case six were considered instead of ICAO's four: Core, Safety and Security, Service Quality, Productivity/Cost Effectiveness, Financial/Commercial, and Environmental. Under these six areas, 42 performance indicators are presented.

With regards to Information Technology, no indicator has been mentioned or indicated. However, the guidebook includes technology as a driver or factor that will have an impact on an individual performance indicator. For example, the performance indicator Security Clearing Time (under Service Quality) measures the average clearing time during the security process, and the drivers or factors that will impact the performance are security staffing level, the type and the number of the screening technology deployed, number of lanes and passenger profile. In this case, technology is an aggregated component of the indicator.

The ACI guidebook on airport performance, unlike ACRP 19A, considers the impact of technology on performance, albeit as a driver (factor) that contributes to the results of the performance indicators.

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<sup>9</sup> ACI: "Airports Council International (ACI) is the only global trade representative of the world's airports. Established in 1991, ACI represents airports' interests with Governments and international organizations such as ICAO, develops standards, policies and recommended practices for airports, and provides information and training opportunities to raise standards around the world. This section provides you with information on the structure and background of ACI".

The indicators where technology was considered as a driver are shown in Table 3 below.

Performance Area	Performance Indicator	Technology Driver
Service Quality	• Security clearing time	• Screening technology • Number of devices
	• Border control clearing time	• Deployed technology
Environmental	• Carbon footprint	• Heating, Ventilation, and Air Conditioning (HVAC) system • Emission control technology
	• Utilities/energy usage per square metre of terminal	• Building management system • Deployed technology

**Table 3. ACI performance indicators impacted by technology.**

There are hundreds of performance indicators available to airport managers, but only two IT indicators have been identified, whilst for other indicators it is a factor that contributes to performance, as shown in Table 2 above.

This demonstrates that the current view is that IT is an aggregated factor of an individual performance indicator and not necessarily an indicator itself, bar the exceptions described in the ACRP 19A.

### **2.2.1.1 Mapping of the traditional performance indicators**

Using ACI Guidebook definition for the six performance areas (core, safety and security, service quality, productivity/cost effectiveness, financial/commercial, and environmental) to group and map the traditional performance indicators against the proposed indicators in the ACI Guidebook and ACRP 19A, which can be found in the Appendix A.

The definitions used by ACI are self-explanatory except for the definition of the core area, whose indicators are used to define the airport according to characteristics such as size (i.e. number of passengers).

The mapping of the traditional airport performance indicators tend to concentrate on economic and operational performances, but these should not be the only areas of the airport business that need to be considered (Graham, 2005).

There are no traditional airport performance indicators to measure performance in the service quality and environmental areas, nor technology-related performance indicators.

However, the traditional performance indicators are still useful to be used as tools to identify potential areas for improvement (self-assessment), but also to compare an airport's performance against that of other airports.

## **2.2.2 Airport performance benchmarking**

As described in the previous section, the measurement of airport performance is widely accepted not only by airport operators and airport managers, but also by other stakeholders of an airport. Airlines may use performance indicators to determine how airports in their network are efficiently managed (Graham, 2005). The previous section presented single productivity measures such as Total Costs per WLU.

The section below presents multi-dimensional measures for airport performance benchmarking.

### **2.2.2.1 Airport performance benchmarking methodologies**

This section presents key methodologies that are used in the airport industry to measure airport productivity. Approaches using single dimensions are simple, because productivity is assessed by dividing one output by one input. However, for an overall picture, the use of multi-dimensional methodologies have been used in the industry. The methodologies are Total Factor Productivity (TFP), Variable Factor Productivity (VFP), Stochastic Frontier Analysis (SFA), and Data Envelopment Analysis (DEA).

#### **Total Factor Productivity (TFP)**

TFP is a useful approach to combine multiple inputs and outputs of airport activity, and parametric TFP method estimates the productivity or efficiency variable by considering the effects on total output caused by other influencing variables such as ownership, economies of scale and scope.



The non-parametric index number TFP method aggregates all outputs and all inputs into weighted indexes of outputs and inputs, with price being used as the weight. But owing to difficulties in obtaining price information, cost and revenue shares are used instead.

However, the drawback of this methodology is that it assumes all airports operate efficiently and it disregards the external factors that influence an airport, such as regulatory environment or ownership structures that are outside the control of an airport, but are expected to have an impact on the efficiency of an airport.

### **Variable Factor Productivity (VFP)**

The VFP uses a similar approach to the TFP, but instead it measures airport performance by using variable input factors. This methodology has been used by Air Transport Research Society (ATRS) to produce their annual Airport Benchmarking Report.

VFP is useful to provide ranking within a sample set.

### **Stochastic Frontier Analysis (SFA)**

The parametric SFA method that estimates production or costs functions to derive an efficiency frontier, and an airport is considered efficient if it operates on that frontier. It is useful to provide ranking and benchmark airport performance. SFA requires large datasets to obtain “*fairly robust efficiency estimates*” (Liebert, 2011, p. 50).

Pels et al. (2003) used SFA to estimate the production frontiers of European Airports and concluded that “the average airport is operating under constant returns to scale when handling Air Transport Movements”. Oum et al. (2007) used SFA to determine the airport ownership models and their effect on efficiency, which showed that private airports are more efficient than public airports. However, in the SFA model used by Malighetti et al. (2010) showed a different result from Oum (i.e. public airports are more efficient than private airports). The reasons for the difference in the results are that public airports are willing to

subsidise airlines enabling airports to have higher utilisation rates of the assets whilst private airports focus on increasing profits and budget constraints.

SFA as an alternative to DEA allows “*technical inefficiency and acknowledges the fact that random shocks outside the control of producers can affect output*” (Muller, 2009).

### **Data Envelopment Analysis (DEA)**

The DEA is a non-parametric method that uses linear programming to construct the efficiency frontier by ranking of the relative efficiency of decision-making units (DMUs).

DEA provides the comparison measure, but does not provide a complete ranking. Instead, it separates the sample into relatively efficient and inefficient units. Vogel and Graham (2006) state that “one of the major reasons why DEA has become a more popular technique than the TFP methods is because of its less demanding data requirements”.

#### **2.2.2.2 Airport Service Quality**

As described in Subsection 2.1.2 Management and its preference, with regards to the deployment of Service Level Agreements, is closely related to the focus airport owners and managers are placing on Airport Service Quality.

An evolution of the airport business from an approach based on level of service to a quality of service where the focus is the passenger. The recognition of an airport’s quality of service enhances an airport’s brand, and it is of “*increasing importance of a customer orientation to competitive advantage*” (Fodness and Murray, 2007). Airport Service Quality surveys, or service quality measures, are not only used for benchmarking purposes but also to identify areas for improvement (Yeh and Kuo, 2002).

Airports can be recognised for their quality of services by receiving awards such as those given by ACI as part of its Airport Service Quality programme, and by

SkyTrax<sup>10</sup>. These awards recognise airports in different geographical locations, and their sizes, for the quality of services provided to their passengers. The methodology used by both entities are the surveys of passengers about their airport experience such as facilities, check-in and food outlets, to name a few.

The focus of Airport Service Quality surveys is to measure the quality of passenger-oriented services and, according to Lubbe et al. (2011), it is important to consider the passengers' expectations of the services provided. Therefore, it is important to hear directly from the passenger (Chen, 2002).

To ensure that there is a common approach to designing services focused on the passenger experience, ACI Europe (2014) published a guideline for passenger services at European airports to help airports to enhance the services provided to their passengers. These are:

- Having the passenger-centric business;

- Understanding the passengers' needs and expectations throughout their airport journey;

- The effect of the 3P (premises, processes and people) on the passenger experience (e.g. comfortable boarding area, automated processes (check-in) and airport staff);

- Providing the services that enhance the passenger experience (e.g. free Wi-Fi); and

- Technology (present and future) that will benefit the passenger experience (i.e. way finding technology to enable passengers to find the location and distance of their gate)

The Airports Council International Airport Service Quality (ACI ASQ) is one of the leading passenger satisfaction surveys covering over 250 airports worldwide, with information collected at the airport. The ASQ also provides a benchmark for

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<sup>10</sup> SkyTrax annually publishes the World Airline Survey and World Airport Survey as leading, independent, global surveys of airlines and airport front-line quality performance.

the airport's performance against that of its peers in the same size category and geographical location. Using key performance indicators, it helps airports to determine areas in which it is under-performing, over-performing and areas that require improvements.

The ASQ has eight major categories covering 34 service areas, and these categories are:

- I. Overall passenger experience
- II. Check-in (e.g. courtesy, efficiency queuing time)
- III. Security (e.g. courtesy, efficiency queuing time, feeling secure)
- IV. Finding the way through the airport (e.g. ease with which to find the way around, flight information)
- V. Airport facilities (e.g. food outlets, cleanliness of toilets, availability of toilets)
- VI. Access (e.g. ground transportation, parking, availability of trolleys)
- VII. Arrival (e.g. passenger and visa inspection, speed of baggage delivery, customs inspection)
- VIII. Airport environment (e.g. cleanliness of the terminal, ambience)

Airports now have two tools at their disposal with which to improve the quality of service at their airports: (1) the guidelines for passenger service, which can serve as a basis despite the fact that the guideline was based on European airports; and (2) the ACI ASQ benchmarking.

The passenger-centric approach to design services means that performance measurement tools such as ASQ, which provides 34 key performance indicators enabling the airport to measure service performance, and may become more prevalent to measure the overall passenger satisfaction at an airport.

The passenger-centric strategies adopted by airports are also reflected in the investments on IT to improve the passenger experience and services provided by airports (SITA, 2013). And the rapid development of technology is also increasing the passengers' expectations of their airport experience (Bogicevic et al., 2013) because passengers have immediate access to information through

social media networks (e.g. Tripadvisor, Facebook, and Twitter) about the services provided by and at airports, which means technology has *dramatically changed how customers learn about services* (Bitner, Zeithaml, Gremler, 2010). And with the introduction of self-service allowing passengers to check-in at home or at the airport using self-service kiosks places the passenger as part of the delivery of service, thus influencing their assessment of the service excellence (Bitner, Zeithaml, Gremler, 2010), which may bring additional challenges to airports.

Bogicevic et al. (2013) also identified service attributes associated with passenger satisfaction or dissatisfaction such as check-in, security check, signage and Wi-Fi, which means they could be happy or unhappy with these three attributes. However, in their findings, the three dissatisfaction attributes of airport service were: (1) signage; (2) security check; and (3) dining options. And these attributes can be addressed by airports as part of an airport's service improvement programme or as part of their service quality initiatives. For example, the importance of service quality improvement programmes is demonstrated by Incheon International Airport Corporation (IIAC), which has been ranked as the No.1 airport in ASQ since 2005, which is the result of Incheon's efforts to enhance the passenger experience through world-class airport management and technology to automate check-in, bag-drop, and immigration clearance, as well as its continued efforts in value creation to their customers (IIAC, 2016).

IIAC indicated that technology is an important element for the airport to maintain their service quality, and Kamarudin (2015) showed that as result of the ASQ surveys, Malaysia Airports adopted three initiatives that leverage on technology to reduce passenger processing time and effort, as well as creating a safe and secure airport. In the same report, Kamarudin concluded that airports should continue their efforts to deploy innovative solutions and leverage them to improve key ASQ areas: passenger processing, safety and security, airport environment, staff courtesy, and customer feedback that in turn will help airports to exceed passengers expectation.

IT solutions that can help the airport monitor or deliver on their ASQ categories as shown below:

Overall passenger experience: airports can monitor this category via an integrated Business Intelligence dashboard that collates information from systems such as immediate feedback solution (e.g. feedback now), data from queuing time, heat zones (i.e. congested areas), and service level monitoring using data analytics will help airports to monitor the overall service quality (SITA, 2014), which will provide airports with data to monitor and improve service delivery, performance and passenger satisfaction.

Check-in (e.g. courtesy, efficiency queuing time): the introduction of self-service check-in options including automated bag drop will have a potential impact on improving the delivery of service and the airport experience (HKIA, 2016). Passenger Flow Monitoring solutions will help airports reduce and monitor wait time using solution to reduce wait time at key touchpoints (i.e. check-in, baggage drop, security and boarding). Airports in addition to monitoring passenger flow, can also keep passengers informed of wait times through use of technology (e.g. notifications via mobile applications) and reduce their stress levels (Mayer, Felkel and Peterson, 2015). Courtesy of the check-in can also be monitored using immediate feedback solution.

Security (e.g. courtesy, efficiency queuing time, feeling secure): there are border security solutions that can speed the immigration controls. Biometric single travel token is one solutions, which captures the passenger's biometric information (e.g. facial image or finger print) and matches it with the passenger's travel document information to create a single digital record (i.e. single token), which will allow the passenger go through check-in, other touchpoints, and border control without the interface with an person. Biometric token has been progressively implemented by Border Control agencies worldwide aimed to improve security, streamline processes, and improve the passenger experience (Robertson et al., 2016). Queuing time at security lanes can be monitored through a Passenger Flow Monitoring, and courtesy of security agents using the immediate feedback solution.

Finding the way through the airport (e.g. ease with which to find the way around, flight information): a number of solutions can be deployed by airports to assist passengers find their way to gates or navigate through the airport such as wayfinding or using signage (e.g. Flight Information Display System) to indicate distances to gates and average walking times. According to Digital Commerce 360 (2015), Orlando International Airport launched a mobile application to help passengers to journey between terminals, to collect their bags or to find their way to ground transportation aimed at increasing passenger satisfaction by reducing stress.

Airport facilities (e.g. food outlets, availability of toilets, and cleanliness of toilets): airports can use their website or mobile application to show the facilities available to passengers. Facilities that include retail and food outlets, lounges, lost property, left baggage, special assistance, toilets, and car parking. Airports also leverage their website as their e-commerce platform to sell services such as car parking, access to lounges (e.g. Heathrow lounge), or online shopping. The cleanliness of toilets can be monitored using immediate feedback solution.

Access (e.g. ground transportation, parking, availability of trolleys): airports can leverage their website to provide information about ground transportation, and parking. Airports can also leverage their website to sell transport-related services (e.g. car parking and train tickets) to passengers visiting their website or through their mobile application. The availability of trolleys can be managed using Resource Management System (RMS) of mobile device (i.e. trolleys and wheelchairs) to ensure that these assets are available when needed.

Arrival (e.g. passenger and visa inspection, speed of baggage delivery, customs inspection): Advance Passenger Processing can speed up the arrival process by providing Border Control Agency with advance information of passengers arriving at the airport enabling them to do a pre-arrival risk assessment, which also allows passengers to use kiosks as part of their arrival immigration process. For example, the United States has recently digitised their arrival cards, and introduced the Electronic System for Travel

Authorisation (ESTA) for eligible passengers arriving in the United States, a solution introduced for a smooth arrival process (US Customs and Border Protection, 2016). Baggage delivery can be improved with deployment of an end-to-end baggage management solution combined with Business Intelligence to monitor the actual delivery time of bags (e.g. first bag on the belt within 25 minutes after flight arrival). And the courtesy of staff through the immediate feedback solution.

Airport environment (e.g. cleanliness of the terminal, ambience): the monitoring can be made using Business Intelligence dashboard because it provides a full view of the airport including potential areas of problem such as congestion (i.e. heat zones) and drop in service levels. The airport can also monitor temperature and lighting to provide a more comfortable ambience by deploying beacons with sensors that constantly emit information such as temperature allowing the airport to control temperature of an area of the terminal with real-time data (e.g. adjust the temperature of the area based on the actual number of people instead of keeping it at a constant temperature).

The relationship between IT and ASQ is described above, which shows how airports can leverage on IT to improve their ASQ indicators because of the direct impact of IT on services delivered by the airport, to monitor the quality of services (i.e. service levels) by enabling the airports to be pro-active in management of the service delivery ensure a high quality of service.

### **2.2.2.3 Airport performance benchmarking: key considerations**

The literature review indicates the availability of large numbers of indicators, ranging from single or multi-dimensional measures, and for them all to provide a meaningful measure of comparison requires data. Therefore, the challenges and issues in airport benchmarking are related to data and how data is treated.

Availability of and access to data is not always possible, because not all airports make operational or financial data readily available. When available, the treatment of data has to be carefully considered, as it may create inconsistencies. For example, in the case of financial data, accounting practices differ from country



to country. Therefore, in the treatment of depreciation of airport assets airports may choose longer periods of depreciation. Table 4 shows three airports and their treatment of different assets and their useful life.

Assets	Miami (MIA)	Beijing (PEK)	Manchester (MAN)
Terminals and buildings	40	8 - 45	10 - 50
Runways, taxiways and apron	30	40	5 - 75
Plant and machinery	5 - 16	5 -15	5 - 30
Vehicles and equipment	5 - 16	6 -12	3 - 10

**Table 4 Airport assets and their useful life.**

Source: ACI Airport fixed assets depreciation (Lioutov, 2015).

Meaningful comparisons can be obtained and this requires the adjustment of data; for example, financial data can be normalised, but will require detailed data in order to apply a consistent accounting standard. However, Tretheway and Kincaid (2009) suggest that due considerations be given to external factors that may impact the comparison and are outside the control of an airport.

These factors are:

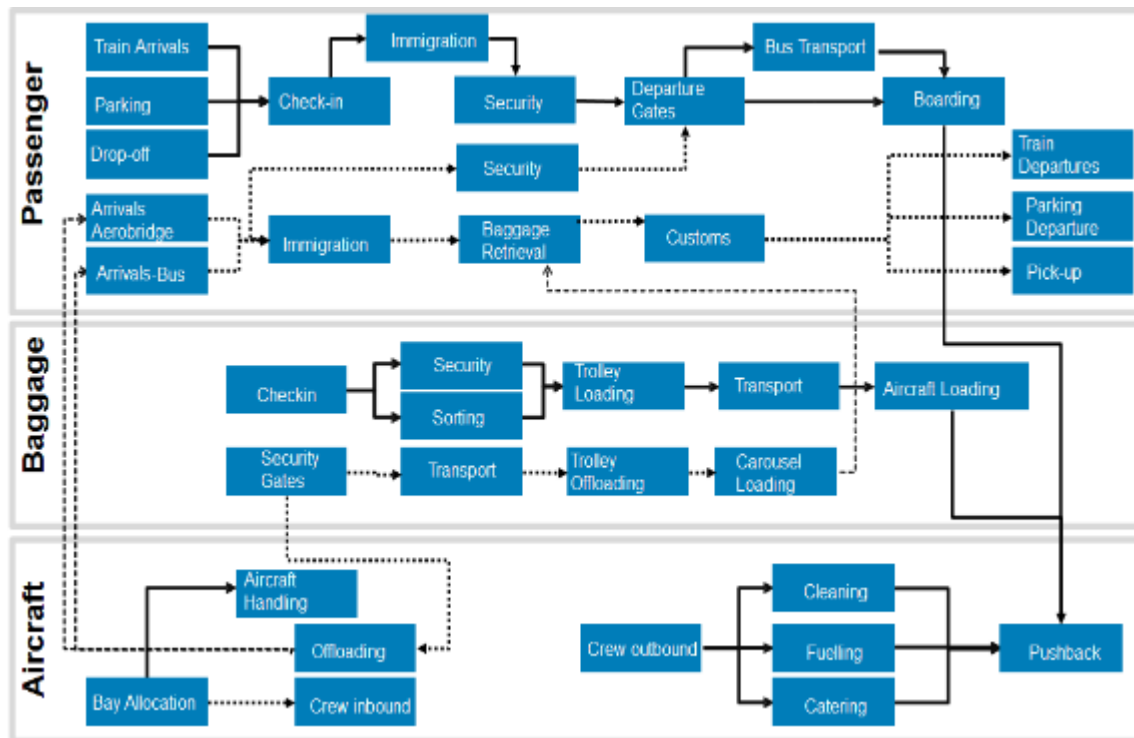
- Weather: Airports in cold climates may require equipment for de-icing and snow clearing, which may increase their costs.
- Subsidies: Publicly owned airports may benefit from government subsidies such as capital costs (e.g. FAA (Federal Aviation Administration) – Capital Improvement Plan used for the distribution of capital improvement funds).
- Traffic mix: International vs. domestic impacts costs, because for the processing of international passengers an airport requires more terminal infrastructure; for immigration for example. The types of operations, with a large number of transfer passengers or simple Origin/Destination traffic have cost and revenue implications.

The airport benchmarking practice is evolving and there are approaches that have been developed to address some of the challenges described above.

In addition, an important element of airport operations and airport management is that an airport operator does not control nor is responsible for some of the key

processes that are measured as part of an airport's performance management system. These include passenger and baggage processing, and aircraft turnaround, which tend to be under the responsibility of an airline or ground handler. There are, however, airports that will undertake ground handling activities (e.g. Domodedovo Airport in Russia).

The diagram shown in Figure 9 shows the activities under the three main processes (i.e. passenger, baggage, and aircraft) with the solid lines representing the departure process, and the dotted lines representing the arrival process. For example, the diagram illustrates the different ways the passenger arrives at the airport, and the processes they have to go through from check-in to boarding the aircraft. The diagram also shows the baggage and aircraft related activities.

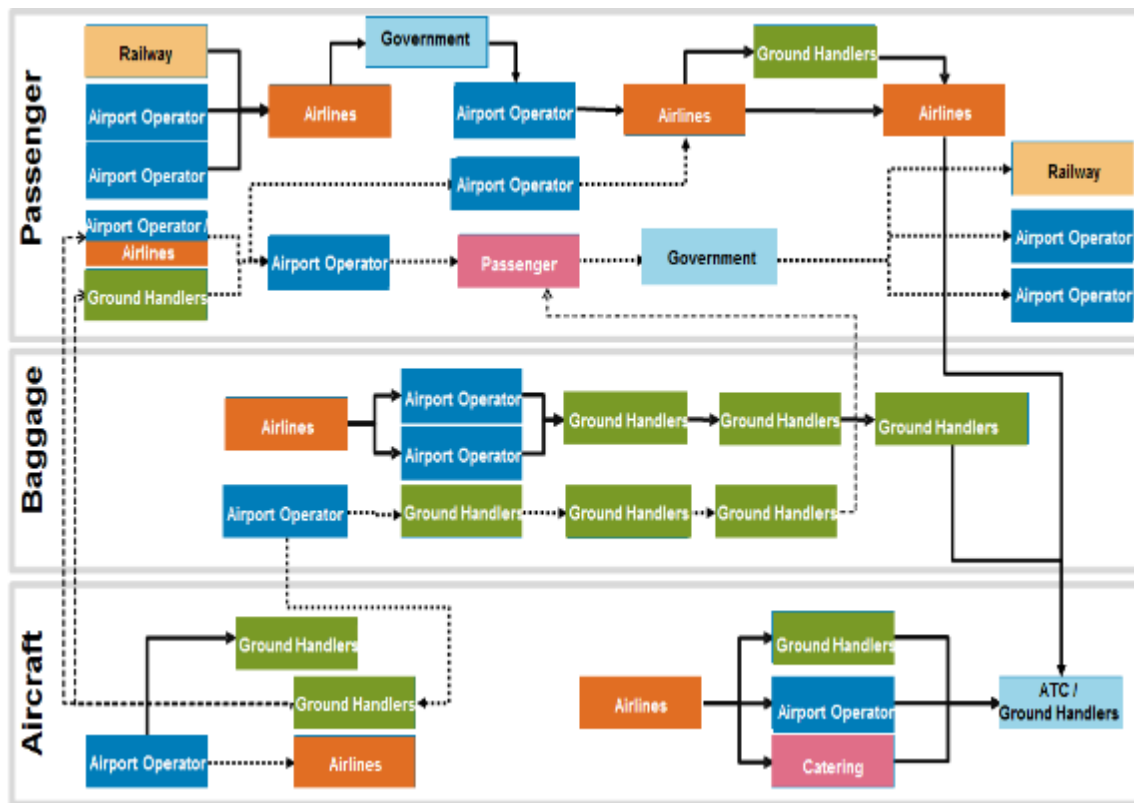


**Figure 9. Key airport processes and activities.**

Source: SITA

While Figure 10 shows the same processes of the diagram above, it overlays the different stakeholders involved in performing those activities, which illustrates the airport's complex stakeholder management. For simplification, some of the activities such as check-in and boarding have been assigned to airlines but it is

common practice for these activities to be handled by a ground handling agent unless the airline self-handles their flights (e.g. British Airways at London Heathrow airport has a team of front-line customer service representatives doing check-in).



**Figure 10. Key airport processes and their respective owners.**

Source: SITA

For an airport, the increased complexity in stakeholder management means addressing the needs of multiple stakeholders because their lack of performance will impact the airport. For example, if the airport deploys a new self-service bag drop solution where the passenger checks-in himself using a self-service kiosk that prints the boarding pass, issues a bag tag, the passenger tags the bag, and places the tagged bag on the conveyor belt to complete the check-in process. In the described process the airport is not involved. However, failures in the process that will result in longer processing time of passenger and/or longer queuing time impact the airport's performance. Therefore, monitoring performance of an airport is a complex activity because of multiple stakeholders involved in major airport processes (i.e. passenger, baggage and aircraft).

Despite the challenges and issues, there is a consensus that airport benchmarking has its merits and value to airport managers, as it provides meaningful ways in which to identify areas of efficiency and inefficiency of an airport (i.e. the performance of an airport).

#### **2.2.2.4 In-practice: airport performance benchmarking methodologies**

A study carried out by Graham (2005) reviewed the situation of airport benchmarking. It acknowledges the “considerable developments” in airport benchmarking and showed evidence of the consistent utilisation of airport benchmarking, where utilisation was shown to be greater in Europe. The study also showed the adoption of new measures such as quality of service and environmental impact.

Although in an early stage, the Airport Carbon Accreditation, launched in 2009 by ACI Europe, can be considered to be a new performance indicator. It will be monitored and verified independently to show proof that airports are committed to reducing carbon emissions.

To overcome some of the deficiencies of traditional indicators, new methodologies have been applied to measure airport performance. Graham’s (2005) study indicated that the methodologies varied from Parametric or TFP (Total Factor Productivity) to non-parametric such as DEA (Data Envelopment Analysis).

ATRS published its global airport benchmarking report in 2002. It used the Total Factor Productivity model comparing productivity and efficiency of 50 airports worldwide (Graham, 2005). Since then, ATRS has adapted the TFP model and is now using the Variable Factor Productivity (VFP), because of the difficulty in obtaining consistent data and differences in the accounting systems adopted by airports (Oum et al., 2003).

The DEA methodology seems to have been more widely adopted because of its simplicity, which requires fewer assumptions and is “*less demanding on data requirements*” (Graham, 2005, p. 11).

This simplicity allows airports to measure their business efficiency or performance by taking into account different variables. Gillen and Lal (1997) used data from 21 airports in the US, and DEA methodology was used to develop performance indicators to measure efficiency of terminal and airport operations. The relevance of the method was that in addition to creating performance indicators, it also provided information on variables that affect performance.

For the planning of airport capacity, DEA was used to determine the efficient use of capacity for 35 domestic airports in Brazil (Fernandes and Pacheco, 2001), which when combined with the airport operators' demand forecast would enable them to determine where capacity expansion would be needed.

The DEA model also enabled the inclusion of "*undesirable output*" such as delay (Pathomsiri et al., 2007, p. 1), which was used to determine the productivity of 56 airports in the US. The study showed that by not including delay, smaller airports tend to be considered more inefficient than larger airports. Noise, another undesirable output, along with environmental factors, was used to measure Taiwan's domestic airports to handle more passengers and aircraft, thus making the expansion of the terminal unnecessary (Yu, 2004).

Airport characteristics, such as size, ownership structures, types of operations (hub-spoke) and economic growth (Lin and Hong, 2006), were considered to determine the operational efficiencies of 20 airports worldwide. Other factors, such as the influence of competition and aviation policy, were used to determine the efficiency of Chinese airports (Yuen and Zhang, 2009), while price factors were used to determine the operational efficiencies of airports in the Asia Pacific region (Lam et al., 2009).

Zakrewski (2006) introduced the "Airport Performance Scorecard" as an approach to measure airport performance for privatised airports, which viewed efficiency from the stakeholders' perspective. The approach takes into account three elements: the customer/client, measuring quality of service; financial stakeholders, measuring finance and operational performance (based on traditional indicators); and community, measuring environmental impact.

From a technology perspective, few studies considered technology and its impact on performance (Jiang, H., 2006; Assaf, 2008; Barros and Weber, 2009; Klann, 2009). Assaf demonstrated that large airports are “*technically more efficient than smaller airports*”, and some of the reasons for the differences may be due to economies of scale and access to technology. The research from Barros and Weber studied the change in productivity of airports, by taking into account the changes in efficiency and technological changes.

In summary, this literature review indicates that most of the studies on airport performance are related to operational performance such as terminal capacity and operational efficiency (measured as passenger, movement and cargo output), and with few studies measuring the impact of IT on airport performance.

This review also indicates that DEA has been shown to be the widely used methodology to measure airport performance. Finally, this review indicates that the current indicators do not provide a direct relationship between IT and airport performance since several factors (size, location and technology) impact the performance of an airport (Assaf, 2008). Therefore, a framework will have to be adapted from other industries to measure the impact of IT on airport performance.

### **2.3 Information Technology (IT)**

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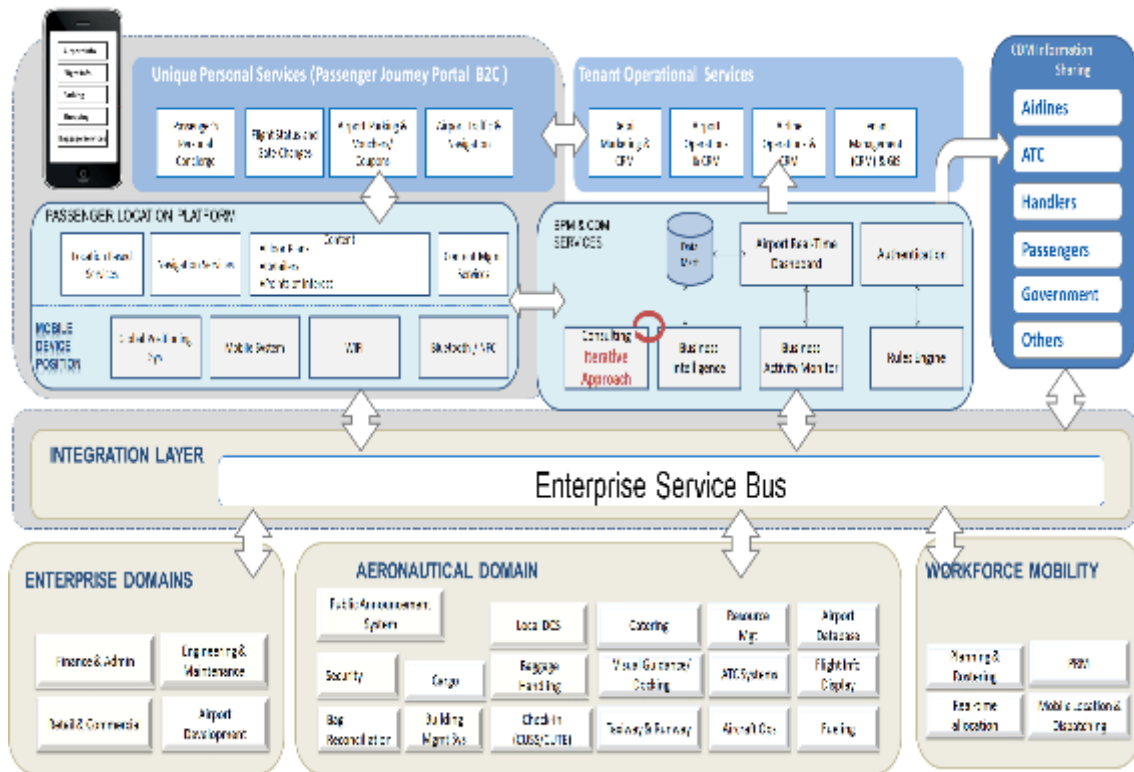
There is considerable value in Information Technology (IT) for airports as the key enabler of all airport processes operating in a constrained environment where passengers are demanding more services. Operational requirements are high, demanding more efficiency from their infrastructure and ensuring the sustainability of an airport, so in this context ACI considers IT as one of its top priorities. IT enables airports to meet the needs of their key stakeholders (i.e. airlines, passengers, ground handlers, and government agencies) in a consistent, efficient, reliable and coordinated manner.

Despite the value of IT, there are limited studies in the area of IT and airport performance to identify or to quantify the effect of technology on the operational and economic performance of an airport.

The value of IT is often described in qualitative statements in marketing brochures of IT solutions that describe the impact of technology and the benefits they bring to airport performance. For example, SITA's Airport Management solution: *"helps optimize performance and revenues, helps to improve planning and operations, minimize disruptions, and optimize mobile workforce, equipment and infrastructure"*.

Klann (2009) in his study "The role of information technology in the airport business" applied the concept of information intensity defined by Porter and Millar (1985) as *"an organization's information intensity is defined and captured by the information intensity of its products' value-chain and the information content contained within those products. A product's information content refers to the amount of useful information contained within that product that is actually received and understood by its users. The information intensity of a product's value chain can be understood as the amount of information processing that is required to acquire process and then deliver the product in its final form to the users."* Klann also identified 12 information-intensive airport processes, of which only the stand and gate allocation process (Resource Management System or RMS) was selected due to the potential influence it has on airport retail operations. Information Technology was used to distribute information and to improve planning processes of both airport and retailers, as shown in Figure 12. The results of the study provided evidence of the impact of IT on improving performance; in this instance, airport retail performance.

The IT schematics in Figure 11 depict an integrated airport with the main operational systems, such as the Airport Operational Database (AODB), Resource Management System (RMS) and Flight Information System (FIDS), all integrated with other systems and sub-systems. The integration of all systems ensures the smoother operation of an airport. This can be achieved because these integrated systems will simplify the collection, storage, processing and distribution of data relevant to these different operational systems.



**Figure 11. Fully integrated airport systems created by the author.**

As result of systems integration, data is entered only once and is then centrally checked and validated. The data input is completed in real time and simultaneously updates all other systems requiring the same data. The real-time sharing of information leads to more effective handling operations, operational flexibility with fewer mistakes and more effective responses to problems. It would also enable an airport to make better-informed decisions and have a clearer picture of opportunities for expanding the service range.

The integration of systems, particularly of the Airport Operational Database (AODB), is becoming more important because it is at the heart of the Airport Collaborative Decision Making (A-CDM)<sup>11</sup> concept. According to the SITA Airport IT Trends Survey (2009), CDM is one of the trends that will improve efficiency and optimise airport operations.

<sup>11</sup> "Airport CDM is the concept which aims to improve operational efficiency at airports by reducing delays, improving the predictability of events during the progress of a flight and optimising the utilisation of resources". European Airport CDM.



Apart from improved operations, an airport will also improve its overall efficiency with an improved and faster flow of information. An airport may be able to reduce its staffing requirements and improve airport capacity by improving throughput rate. Managers can perform better forecasting, with the improved collection and control of statistical data such as passenger numbers, inventory and financial transactions. Airport administration will function more efficiently by reducing billing cycles, therefore increasing cash flow.

The example above describes the intuitive and qualitative benefits that IT brings to an airport. IT plays a critical role in the airport business and to its success. SITA Airport IT Trends Survey (2009) shows that, despite the economic downturn, IT budgets remained stable with no change to their long-term investment strategy. Furthermore, the SITA Airport Trends Surveys show that airports continue to invest in IT to improve operational efficiency.

### **2.3.1 IT culture: the role, importance and benefits of IT**

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Leidner and Kayworth (2006) define IT culture as the “values attributed to IT” in their research providing linkages between IT and culture and IT culture; and the IT culture assumptions (e.g. value of IT in an organisation, strategy role of IT, and benefits of IT) identified by Kaarst-Brown (2004) combined provide a definition of IT culture for this research, which is defined as the role, the importance and the benefits that IT brings to an organisation.

As described in Section 2.4, IT is an enabler of airport processes because it supports airport business objectives. As technology evolves, new IT solutions are introduced and with it new business processes (e.g. biometric identification enabling self-service identification for boarding procedures). The rapidly changing airport environment has to be flexible to accommodate new technologies, new processes and passengers’ expectations (e.g. free access to Wi-Fi), and it requires a strong IT governance to ensure that IT investments are addressing the key business priorities of an airport. Therefore, a strong IT culture, which as defined by with clear definition of the role, importance and benefits of IT.

Gallivan and Srite (2005) defined culture as “*people’s beliefs, values, assumptions, and behavioural norms*”, which is critical to an organisation to achieve the benefits of IT. In the ICAO Economics Manual (2013, pp. 2-5) describes the advantages of autonomous airport entities that have a strong business culture that encourages growth because they are more responsive, and have a good governance resulting in increased efficiency and improved quality of service. This business culture can be cascaded or aligned with an airport’s IT department, which will drive a strong IT culture as well.

The most important aspect of the IT culture is the influence on the adoption and use of IT, thus defining the role of IT (e.g. operational role delivering efficiencies in baggage handling), the importance (e.g. it is a mission-critical system) and the benefits (e.g. reducing costs). It is not the intent of this research to determine the cultural dimensions (i.e. roles, gender, ethnicity, nationality, and business orientation) that influence IT culture.

Technology evolution and changes in passengers’ behaviour mean using IT culture to influence the adoption and use of IT will have the greatest effect in the airport business in four areas: (1) airport operations: by improving an airport’s ability to exchange, process and present information quickly and reliably, enabling all stakeholders to collaborate to improve airport processes through better planning and execution; (2) passenger processing: increased adoption of self-service processes that enable significant reductions in staffing levels and costs, the ability to move check-in off an airport’s premises and, most importantly, increasing an airport’s passenger capacity and reducing queues; (3) mobility: high penetration of mobile devices (e.g. smart phones and tablets), enabling airports to locate and personalise communications with passengers to keep them informed throughout their journey, particularly important during disruptions; and (4) security: integration of biometric technology in the security touch point of the passenger journey that enables the validity and identification of the passenger without the need of staff intervention, thus reducing queues and processing times, and enabling government agencies to assess potential threats.

A strong IT culture, aligned with business objectives, will allow an airport to exploit the benefits of IT investment that can deliver significant improvements in operational efficiency through better planning and operations, and passenger experience by improving processes and empowering the passenger to be in control of the journey.

### **2.3.2 Information Technology and business performance**

Recent studies on Information Technology and economic performance have shown evidence that there is a positive and significant impact on a firm's productivity and economic growth. IT *"is not simply a tool for automating existing processes, but is more importantly an enabler of organisational changes that can lead to additional productivity gains"*. (Dedrick et al., 2003, p. 1).

Dedrick et al. (2003) and Melville et al. (2004) did an extensive literature review of the relationship between IT and business performance. Dedrick reviewed more than 50 empirical studies from 1985 to 2002, while Melville reviewed approximately 200 articles on IT business value from 1990 to 2002. Both studies showed evidence of the positive impact of IT on performance. The positive impact of IT on firm performance can be grouped into two distinct areas: (a) to improve organisational performance and (b) to enhance a firm's competitiveness.

From an organisational performance perspective, the impact of IT is based on the IT intensity that is the level of investment in IT in relation to the company's revenue. The study from Bharadwaj et al. (1997) demonstrated the relationship between IT investment and a firm's Tobin's  $q$ <sup>12</sup> values, and the results of their study showed evidence of the impact of IT on firm performance. Tobin's  $q$  has been widely used to study the impact of *"intangible value of a firm such as R&D, advertising, and brand equity"* (Bharadwaj et al., 1997, p. 10). As part of their research, they analysed the impact on shares of companies that made

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<sup>12</sup> Tobin's  $q$ , named after its creator James Tobin, is a ratio that calculates market value of listed companies in relation to the total cost to replace these companies' assets. It is calculated by dividing the total market value by the total value of assets ( $q = \text{market value} / \text{total assets}$ ). For  $q > 1$  it means that stocks are overvalued and for  $q < 1$  it means the stocks are undervalued. It is mainly used for long-term valuation of stocks.

announcements related to IT investments, which they demonstrated had a positive impact on shares.

One worthwhile conclusion from the research is their explanation as to why Tobin's q is better in demonstrating the positive impact of IT investment and a company's market performance. The arguments in favour of Tobin's q are two-fold: (1) Tobin's q measures a long-term valuation of firm performance which is a reflection of the effects or benefits of IT tend to lag in relation to implementation, a *"naïve assumption underpinning IT investment – "once we get in, the benefits will begin to flow"* (Peppard et al., 2007, p. 4), and (2) measure of the intangible values of IT.

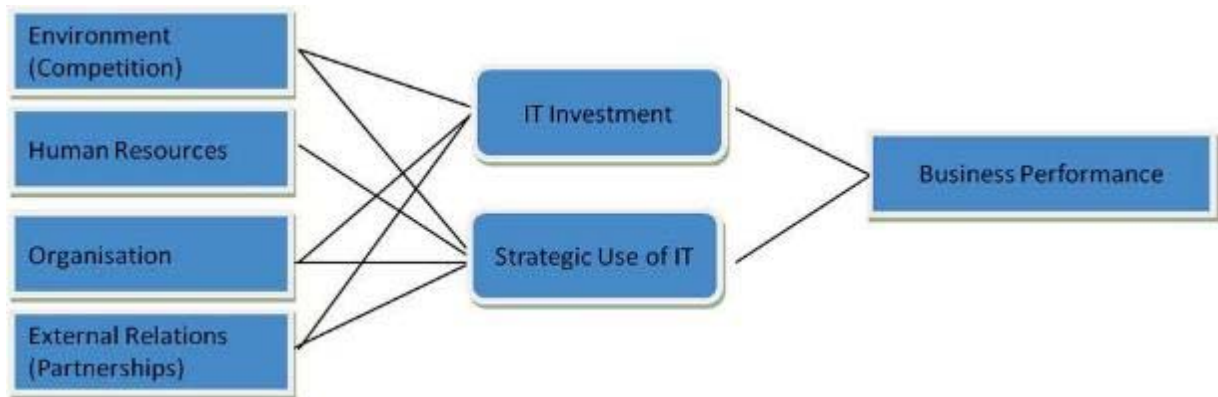
A study by Hu and Quan (2005) investigated the causality between IT investment and firm performance. They created a framework that uses the IT spend at industry level and labour productivity, in this case represented by GDP contribution by industry and to verify the causality they used in the Granger causality model.

The Granger causality model is a statistical test to determine if one time series can be used to predict the future of another time series in econometric models. The model was proposed by Granger (1969) and introduces the concept of *Granger causality* that *"a variable X Granger-causes variable Y if variable Y can be better predicted using the histories of both X and Y than it can be predicted using the history of Y alone"*.

In Huan and Quan's study, using Granger's model is important because by doing so they are able to demonstrate the *"exact nature of the relationship between productivity and IT investments"*. Their conclusion was that at industry level there is a *"causal relationship between IT investment and productivity as well as the feedback relationship from productivity to IT investments"*.

Kim and Jee (2007) also studied the relationship between IT investment and firm performance, and as part of their study, they have also looked at different factors that influence the strategic use of IT and, consequently, its impact on performance. For their study, they created a research framework that took into

account internal (Human Resources and Organisation) and external (Environment and External Relations) factors. This can be seen in Figure 12.



**Figure 12. Kim and Jee's research framework.**

Although it is used for small and medium-sized companies, their framework has the potential to be adapted to the airport industry because their framework uses a questionnaire to obtain data. Hu and Quan's framework, however, requires very specific published data that may not be readily or easily available for airports.

A firm's enhanced competitiveness through IT can be achieved in the following fronts:

**Resources:** Lehr and Lichtenberg (1995) introduce the notion of complementary resources when combined with IT to generate business value. The results of their study provide evidence that *"computers are complementary with skilled labour and that they help reduce inventory levels"*. Other studies on the impact of complementarity are by Brynjolfsson & Hitt, 2003; Melville et al., 2004; Ross et al., 1996.

Mata, Fuerst and Barney (1995) studied the impact of IT on productivity, which in turn gives a competitive advantage to a firm. In his study, he identified four areas that could provide a firm's competitive advantage: *"IT funds, technology, technical IT skills and managerial IT skills"*. However, only IT management skills were considered to provide a sustainable competitive advantage. When IT resources are combined with other resources, IT may also play a strategic role that will impact a firm's competitiveness (Nevo and Wade, 2010).

**Operational:** The investments on IT lead to higher productivity and quality, creating a competitive advantage (Mukhopadhyay et al. (1997); Brynjolfsson & Hitt, (1995); Barua et al. (1995)). An industry that has benefited from the deployment of technology to improve operational performance is the logistic industry, which in order to build a stronger relationship between buyers and suppliers relied on electronic data interchange to share information and the internet (Bayraktar et al., 2009). Collaboration is also an area that airports are looking into to improve operational performance, and Airport Collaborative Decision Making (A-CDM) is one area that relies on technology to exchange information amongst all stakeholders (e.g. Air Traffic Control, Airport, Airlines and Ground Handlers) resulting in significant improvements for airports (Laplace, Marzuoli and Feron, 2014).

**Financial:** According to an OECD (Organisation for Economic Co-operation and Development) Report, “Economic ICT – Impact of Information and Communications Technology, (2004), it states “*studies with firm-level data often find the strongest evidence for economic impacts of ICT*”. However, the impact on a firm’s profitability cannot be attributed to the technology itself but other factors have to be considered such as business strategy (Shin, 2001), technology competency (Perez-Lopez, Alegre, 2011), and data quality (Kwon, Lee, Shin, 2014). In addition to evidence of the impact on performance, as described above, the next paragraphs also show that certain characteristics, such as leadership and strategic directions (Brynjolfsson and Hitt, 1995), explain the reasons some organisations deploy IT more productively than others.

### **2.3.2.1 IT reporting structure and performance**

The question of the ideal CIO reporting structure (i.e. reporting to CEO or to CFO (Chief Financial Officer)) is “yet to be prescribed” according to Banker, Hu, Pavlou, and Luftman (2008). Their opinion is that the reporting structure should be driven by the company’s strategic directions, and they tested two structures: (1) CIO reporting to the CEO with the objective of using IT to innovate and to enhance, or to bring new products or services to market; and (2) CIO reporting to the CEO with IT playing a custodian role (i.e. responsible for all IT matters), with

the focus on operational capabilities of IT. The result shows that having a clear strategic direction and clearly defined reporting structure influence a company's performance. In a similar study, Hu, Yayla and Lei (2014) show that having the CIO as one of the top senior executives has a significant, positive effect on firm performance.

According to the 2007 survey by the Centre for CIO Leadership, a global community of academic researchers, practitioners and business leaders, shows that more businesses are recognising the contribution of IT on innovation and competitive advantage. As result, CIOs are taking more prominent roles within their organisations and becoming key contributors to their organisation's strategic directions, and according to Watson (1990), as the distance between the CIO and CEO increases, the influence of IT diminishes. Therefore, an organisation that shows stronger commitment and understanding of the role of IT in the organisation, benefits from a positive impact on performance (Cohen and Toleman, 2006).

The organisational importance of IT is becoming more prominent to deliver a competitive advantage to an organisation, which is validated by surveys carried out by companies such as IBM, PricewaterhouseCoopers (PwC) and Gartner, to name but a few that have presented similar results.

IBM CIO Survey (2011): *"Technology has become ubiquitous and data is expanding exponentially. In turn, the role of the CIO is growing more critical to organizations across the globe"*. IBM also carried out a CEO survey, and one of the findings was that CEOs and CIOs have a strong strategic alignment that was demonstrated by their ranking of the external forces that would have a strong impact on their organisation: market forces, technological factors and macroeconomic factors.

And in the same year, 2011, PricewaterhouseCoopers's CEO Survey showed that *"85% believe innovation will result in operational efficiencies that give their companies competitive advantage. Technology is one way to realise that goal. 82% of CEO are investing in IT to reduce costs and become more efficient."*

Gartner 2011 CIO Agenda: “*CIO IT strategies for 2011 focus on creating infrastructure while streamlining costs and operations. CIOs intend to redefine the essential elements of IT – from infrastructure, to cost structure, to people, to processes. Moreover, they see each of their strategies as intimately connected with business strategies*”.

Having a clear, strategic direction and leadership are important characteristics that showed the impact of IT on performance. So is the alignment of IT and business strategy (Tallon et al., 2000). In addition to supporting the firm’s business strategy (Klann, 2009), IT can be used to provide a sustainable competitive advantage, and Melville et al. (2004, p. 13) indicate that the resource, in this case IT, should meet the following criteria: “*value, rareness, inimitability, and non-substitutability*”.

Loveman (1994) validates what IT practitioners normally preach to their clients about the importance of making organisational changes with the implementation of IT in order to capture the benefits of IT to the organisation. The transformational aspect of IT is evident when it is combined with “*changes in strategy, form structure and work practices*” (Brynjolfsson and Hitt, 2000, p. 7).

Dedrick states that IT can impact in two ways: first, by improving labour productivity, and in the study he used the example of a banking system to process transactions. Similarly, with airports the deployment of a Common Use Terminal Equipment (CUTE) system enables airport staff to process passengers from different airlines using the same terminal equipment, which in principle abolishes the need for dedicated check-in areas. The second way relates to the changes that IT brings to an organisation in terms of business processes and organisational structure, which in turn “*enhances the firm’s Multifactor Productivity*” (MPF)<sup>13</sup>.

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<sup>13</sup> Multifactor Productivity is defined as the increase of output without the increase of investment.



### 2.3.2.2 IT governance and performance

Another aspect of IT that impacts performance is governance, which is defined by Gartner as “the processes that ensure the effective and efficient use of IT in enabling an organization to achieve its goals”. IT governance provides companies with a framework within which IT is sourced and applied in a correct manner, a discipline that is adopted across all functions and throughout the company (Weil and Aral, 2006).

There are several ways to represent IT governance, Figure 13 shows an example of governance with three distinct areas: strategic, tactical and operational. The first is oversight, to ensure the strategic value of IT and alignment. The second is the tactical area, which is about management of performance where priorities of IT are set and how the IT budget is spent is decided. The third is the operational area, in which priorities are properly communicated to ensure strategic alignment, projects are properly monitored and controlled in terms of budget and implementation, and there is a focus on continuous improvement in operations of systems. An integral element of any IT governance is the inclusion of clearly defined performance measurements to ensure IT is delivering against the business objectives of the company.

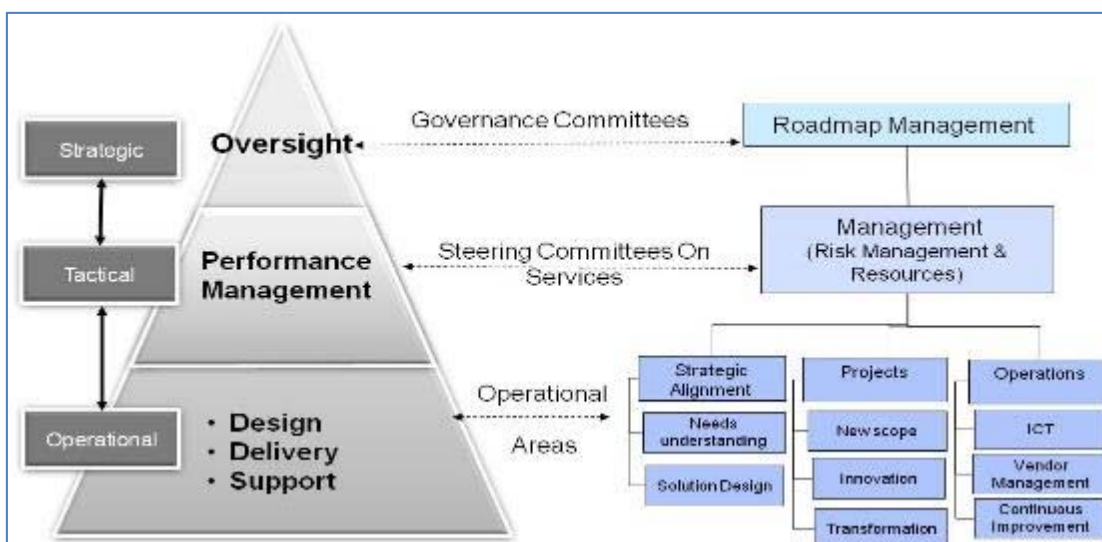
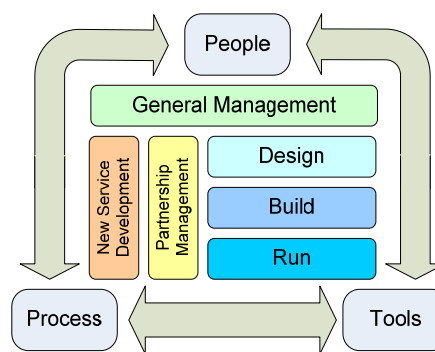


Figure 13. Author proposed generic IT governance structure.

The key elements that should be considered in the development of the appropriate IT governance structure are IT technology (i.e. infrastructure, assets, systems, and data), IT people, IT processes (e.g. COBIT<sup>14</sup>, ITIL<sup>15</sup>), IT support systems and tools (e.g. network monitoring systems, help desk tools and contract management), IT vendor management.



**Figure 14: Key elements of an IT governance: people, processes and tools.**

The example above draws on best practices to design an effective IT governance. Good IT governance uses IT to improve a company's performance (Zhang, Zhao and Kumar, 2014), and with effective and efficient use of IT assets and IT resources (e.g. people) it is more likely to gain a competitive advantage to improve performance. Companies have shown to have improved profitability as result of having adopted IT governance practices, and the significant improvement was shown to be in the year following the adoption of the governance (Lunardi et al., 2014).

## 2.4 Impact of IT on airport performance

The value of IT is accepted, because automation leads to productivity increase (Brynjolfsson and Hitt, 2000). However, Oz (2004) concludes that there is no conclusive results of IT productivity at company or country level. Oz argues that companies continue to invest in IT, despite the issue of the IT productivity

<sup>14</sup> COBIT is "framework for the governance and management of enterprise IT is a leading-edge business optimization and growth roadmap that leverages proven practices, global thought leadership and ground-breaking tools to inspire IT innovation and fuel business success". <http://www.isaca.org/cobit/pages/default.aspx>

<sup>15</sup> ITIL ("IT Infrastructure Library) is essentially a series of documents that are used to aid the implementation of a lifecycle framework for IT Service Management. This customisable framework defines how Service Management is applied within an organisation. It is also aligned with the international standard, ISO 20000". <http://www.itil.org.uk/>

paradox (i.e. high investment in IT resulting in very small productivity gains), because of the intangible benefits that it brings (e.g. better decision-making).

A highly publicised debate on the IT productivity paradox was the article “IT Doesn’t Matter”, written by Nicholas G. Carr and published by Harvard Business Review (2003), which initiated a series of debates about the strategic importance of IT in business.

The controversy and debates created by the article was due to Carr’s argument that IT has lost its strategic importance because of IT commoditisation and how it diminishes a firm’s competitive advantage (McFarlan and Nolan, 2003). However, it is important to clarify that Nicholas Carr’s argument was not that companies do not need IT nor that it is not important, but he argues “*it doesn’t matter strategically*” and does not give a company a competitive differentiation.

The debate for and against Carr’s argument continues, but the key arguments on the subject of “IT doesn’t matter” can be summarised in two areas: (1) Ubiquitous IT and commoditisation; and (2) Reduced Differentiation. However, there is no straightforward answer, as there are arguments both in favour of and against these two areas.

The argument that IT does not matter because of the ubiquity of technology making its use more widespread (easily integrated) and due to its commoditisation, give little or no strategic differentiation to companies when deploying such technology. However, the opposite argument is that with ubiquitous technology comes standardisation, although alone it will not deliver an advantage to a company.

This technology will matter depending on how it is deployed to bring cost savings and/or operational efficiencies to a company, enabling it to focus on other strategic areas to enhance its competitiveness. “*Pervasive application of general-purpose technologies, thus, eliminated cost asymmetries between competitors whilst stimulating niche strategies aimed at the introduction of product innovations.*” (Consoli, 2005).

Following the same argument, as a result of commoditisation there is reduced differentiation because competitors have the same access and prices to those commoditised technologies. Therefore, IT potentially has limited relevance to a company's competitive position.

The counter argument to the above statement is that even with commoditised technologies, companies can create a sustainable competitive advantage when there is an alignment with the company's culture, processes and strategies. One example is the deployment of Flight Information Display Systems (FIDS), of which almost every airport has one installed. The differentiator will be how it will be used; in Rome Fiumicino Airport for example, FIDS is used only to display flight information, whilst at Amsterdam Schiphol it also displays multimedia content, enabling the airport to generate additional revenue from advertisements.

So, the argument that IT doesn't matter can be challenged, which was the case when professors McFarlan and Nolan from Harvard Business School responded to Carr's article. Both professors argued that IT does matter and presented their arguments as to why. One can also argue that in the airport industry, there are examples where IT clearly does make a difference.

*"IT transforming potential"*: The ability to do things differently to achieve a competitive advantage. Hong Kong International Airport deployed RFID (Radio Frequency Identification) baggage tags for all baggage operations at the airport. The deployment of RFID will increase the read rates of the bag tags to 97% compared to 80% of barcode tags – a vital improvement for a hub airport – as well as reducing the number of mishandled bags, which cost the industry US\$2.5 billion in 2009 (SITA Baggage Report 2010).

*"IT's associated economics"*: Gaining benefits from the reduction of transaction costs. The deployment of self-service kiosks can generate savings of approximately US\$2.50 per checked-in passenger (SITA Airportconnect kiosk). According to the 2010 SITA Airport IT Trends Survey, 72% of respondents already deployed or intended to deploy self-service kiosks to handle passenger processing at airports.

Business Intelligence (BI): *“to expand the customer value proposition by providing more intangible information-based services”*. The deployment of tools to generate Business Intelligence to enhance the Collaborative Decision Making (A-CDM<sup>16</sup>) process of an airport through the real-time exchange of information amongst key stakeholders. Approximately 75% of airports intend to enable critical exchange of information, the first step towards A-CDM (SITA Airport IT Trends Survey 2010).

*“Differentiation”*: Bring to market new products or new features. Dusseldorf Airport is one example of bringing new products to market; travel portal enabling passengers to book flights and hotels directly on the airport’s website.

*“Innovation”*: Foster the incubation of new solutions with the introduction of new technology such as open operational platforms. Copenhagen Airport announced in March 2011 the deployment of augmented reality (AR)<sup>17</sup>, enabling passengers to use their mobile devices (e.g. smartphones and tablets) to obtain information about the airport such as gates, shops, restaurants, and other information in a more interactive manner.

Other airport examples that describe the relevance of IT are shown as opinions of senior executives from three airports (i.e. Kuala Lumpur, Ulaanbaatar, and Sydney) who the author met at industry conferences, and references to the importance of IT for Hong Kong and Incheon are from their strategy documents, which are shown below.

- Kuala Lumpur International Airport, CEO: Technology is very important. Airports should work closely with their airline tenants to ensure that the technology deployed by them also delivers benefits to all. He cited the

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<sup>16</sup> Eurocontrol: *“The objective of the Airport CDM (Collaborative Decision Making) is to improve the overall efficiency of operations at an airport, with a particular focus on the aircraft turn-around procedures. This is achieved by enhancing the decision-making process by the sharing of up-to-date relevant information and by taking into account the preferences, available resources, and the requirements of those who are involved at the airport (such as airline operators, air traffic control, handling agents, and the airport management)”*.

<sup>17</sup> According to Online Oxford Dictionary: *“Augmented Reality – a technology that superimposes a computer-generated image on a user’s view of the real world, thus providing a composite view”*.

deployment of special gate readers, which were needed as a result of Malaysia Airlines introducing mobile phone check-in.

- Ministry of Civil Aviation of Mongolia, Economic Advisor: IT is an important component of the New Ulaanbaatar International Airport. The intention is to extend some of the airport's new technology, such as broadband and telephony, to the community in the new airport's catchment area.
- Sydney International Airport, COO (Chief Operations Officer): In addition to deploying IT to improve the airport's operational efficiency, they are now looking at the commercialisation of IT to generate new revenue streams. In this case, it refers to the provision and commercialisation of Professional Mobile Radio systems to tenants.
- Hong Kong International Airport and Incheon (Seoul) International Airport have IT as a key strategic direction to deliver on their vision. For Hong Kong, it means IT is key to delivery on its e-airport vision; as for Incheon, IT is one of its six strategic directions to deliver their 2030 Vision of becoming the world's best hub.

The literature reviewed shows that the studies assessing the relationship between IT (i.e. specific systems or IT solutions) and airport performance can be categorised into two domains: airport operations and airport management.

In the airport operations domain, the focus is on the allocation of resources, though the type of resources varies (e.g. check-in desks, gates, parking stand and baggage carousels). For example, the allocation of common use, check-in counters (Yan, Tang and Chen, 2004) using an allocation algorithm tested at Taoyun Airport (Taipei), with preliminary results showing potential usefulness of the algorithm. Klann (2009) demonstrated that retail revenues can increase with an alignment between business and IT functions (i.e. airport retail and gate allocation system), therefore demonstrating the impact of an IT solution on airport retail performance. The deployment of airport resources has also been used in simulation tools to assess terminal efficiency, as well as being used in airport planning and terminal design. Manataki and Zografos (2009) proposed a model to analyse terminal performance and tested it using real data from Athens Airport,

confirming the direction of the changes in performance as a function of reduction in resources (e.g. reduction in passport control desks and deterioration in performance as a result of an increase in waiting times). For planning purposes, Kalakou, Psaraki-Kalouptsidi and Moura (2014) simulated the impact of technology innovations (e.g. Near Field Communications<sup>18</sup> (NFC), biometrics, big data analytics, and mobile applications) on passenger processing. The results show a reduction in processing time at check-in and security check points, which resulted in capacity gains and put into question the need for terminal expansion. IT solutions such as Common Use Terminal Equipment (CUTE) and Common Use Self-Service (CUSS) kiosks are used to simulate terminal capacity requirements as part of an airport's terminal planning and design. These solutions have been incorporated into planning manuals such as IATA's Airport Development Reference Manual, as well as ACRP Report 25 – Airport Passenger Terminal Design V2. Airport operators have available a wide range of IT solutions (e.g. airport Resource Management System) that can help them to plan and allocate their resources for day-to-day operations, as well as for long-term planning and simulations.

In the airport management domain, Jiang (2006) discusses the role of the internet with regards to the improvement an airport's economic performance, particularly by increasing revenue per passenger and reducing costs per passenger. The study demonstrates that with the deployment of a web strategy that increased its presence in the market, Manchester Airport was able provide targeted services to customers (e.g. car parking offers) that improved customer satisfaction, resulting in an increase in revenue per passenger. In terms of using the internet to reduce costs through the deployment of an e-commerce platform, it enabled airports to cut intermediate costs by directly targeting its passengers (i.e. moving from a business-to-business (B2B) model to a business-to-consumer (B2C) model). Manchester Airport's website provides a good illustration of how airports

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<sup>18</sup> NFC is wireless technology that enables contactless transmission of data. In 2013, IATA published a NFC Guide for Air Travel that presents different uses of NFC in the industry (e.g. boarding pass on a passenger's device, which is easy to use. Compared to a mobile boarding pass that does not require a browser app, which works even if a mobile phone battery is low).

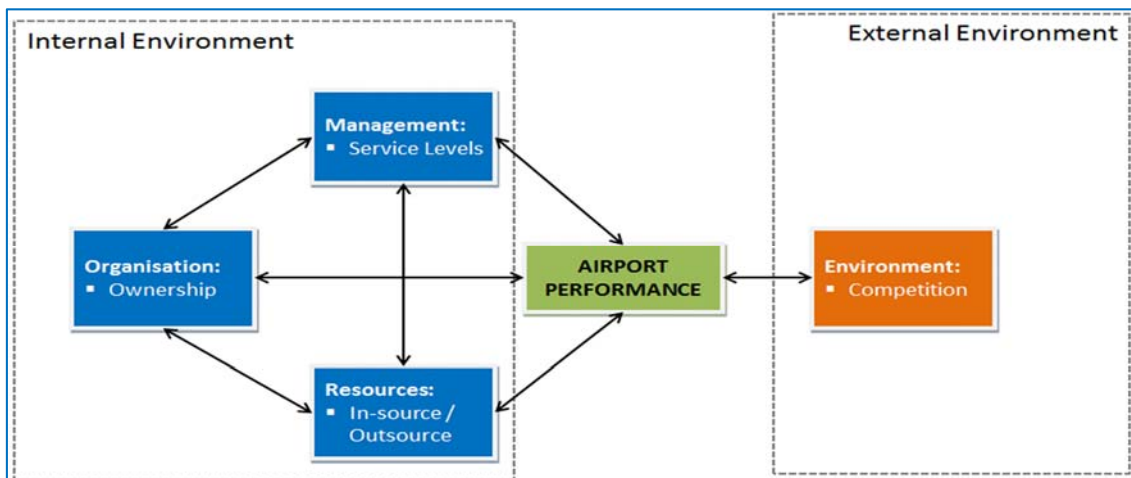
are promoting additional services directly to its passengers; for instance, car parking offers, lounge access, and flights and holiday offers from Manchester. However, this study does not demonstrate quantitatively the impact of the internet, it simply demonstrates that it exists.

In summary, this section shows that IT matters and that it plays an increasingly important role in the airport industry, which also recognises the benefits of investing in IT to gain operational efficiencies to enhance their financial and operational performance. However, the aim of this research is to assess if this relationship can be empirically demonstrated for the airport industry as a whole and not just on the implementation of specific systems.

## 2.5 Summary of the Literature Review

A systematic approach was used in the literature, with the search centred on four areas: an airport and its characteristics, airport performance, IT, and airport performance and IT.

There are several factors that can contribute to the performance of an airport, such as airport size and ownership structures. Other characteristics have been identified to impact performance: the competitive environment in which an airport operates, management preferences regarding service levels and human resources. Figure 15 shows the key airport characteristics that impact airport performance.



**Figure 15. Key airport characteristics that impact airport performance.**

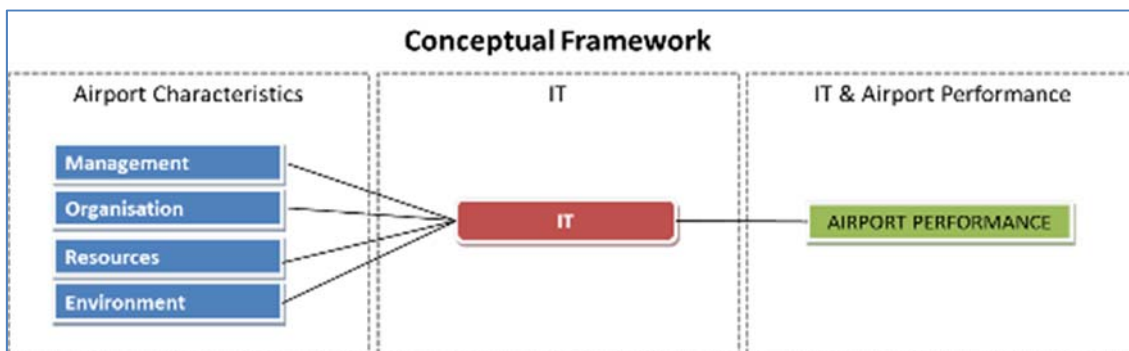
Author adapted from Fry and Killing (2000).



The review of the airport performance literature shows that the only availability of an IT system is recommended as a performance indicator because of a failure in a critical system – for example, failure in the baggage handling system – could cause a major operational disruption to an airport. Other than system availability, the literature review could not identify IT-related indicators to measure its impact on airport performance.

The review of the IT literature provides evidence that IT does matter and has a positive impact on the performance of a firm. The literature also provides sufficient information to adapt models and frameworks used by other industries to measure the impact of the IT on performance. An important aspect of IT is the IT culture (i.e. the role, importance and benefits of IT) and its impact on performance.

The literature reviewed shows a gap that currently exists in the study of the impact of IT on airport performance. Therefore, to address this gap the conceptual framework (Figure 16) is proposed as result of the literature review of performance in the airport industry, which uses a model used in other industries to determine the impact of IT on a firm’s performance.



**Figure 16. Conceptual framework of the impact of IT on airport performance.**

The framework was adapted from a model proposed by Kim and Jee’s research to determine the relationship between IT and firm performance.

The framework aims to test the impact of airport characteristics on IT culture and how it impacts airport performance.

## **3 RESEARCH QUESTIONS AND HYPOTHESES**

### **3.1 Overview of research questions**

This chapter focuses on the following six research objectives that have been established to address the aim (i.e. the assessment of the relationship between IT and airport performance) of the study.

- To determine IT culture and its relationship to airport performance through understanding of the role, importance and benefits of IT.
- To determine the airport IT characteristics that have an association with airport IT culture
- To determine if airport IT characteristics have an association with airport performance.
- To determine the relationship between IT investment and airport performance.
- To determine from selected IT Systems the ones that have an association with airport performance.

### **3.2 Hypotheses**

As a result of the literature review, a conceptual framework has been developed to address the objectives of this research. Figure 17 shows six hypotheses that test the relationship between IT culture and airport performance. In H1, the relationship between IT culture and airport performance; in H2a, H2b, H2c and H2d, the airport characteristics (i.e. preference for SLA, ownership structure, outsourcing from a resource requirement and competitiveness of the airport environment, respectively) that have a relationship with IT culture; and H3, which is used to test the relationship between airport characteristics and airport performance.

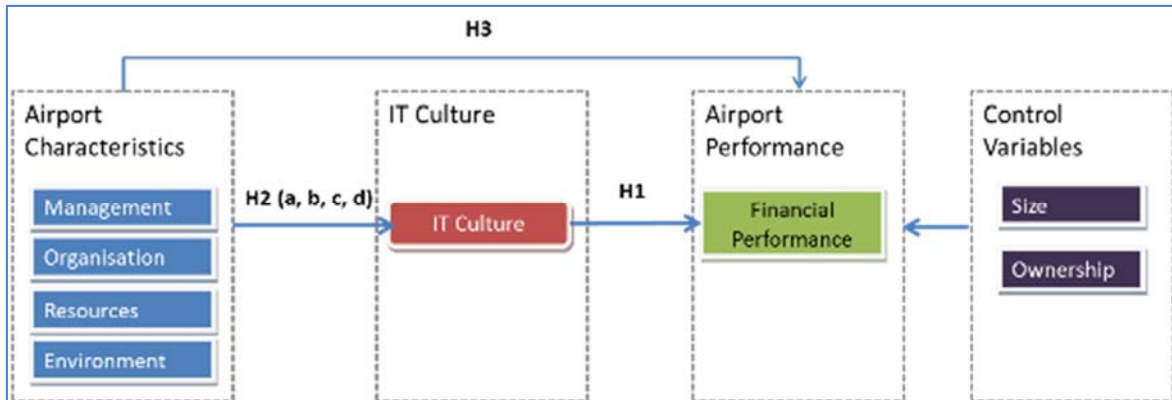


Figure 17. Research hypotheses: airport characteristics and IT culture (part 1 of 2).

H1: There is a relationship between IT culture and airport performance

H2a: There is a relationship between management preferences to use Service Level Agreements (SLA) and IT culture

H2b1: There is a relationship between ownership structure and IT culture

H2b2: There are differences in IT culture based on variation in ownership structures

H2c: There is a relationship between outsourcing and IT culture

H2d: There is a relationship between competition Intensity and IT culture

H3: There is a relationship between airport performance and airport characteristics

Figure 18 shows three hypotheses: H4 to test the ASQ dimensions on airport performance (e.g. passenger satisfaction); H5 to test if IT investment has an impact on airport performance; and H6 to test from a list of pre-determined systems their impact on airport performance.

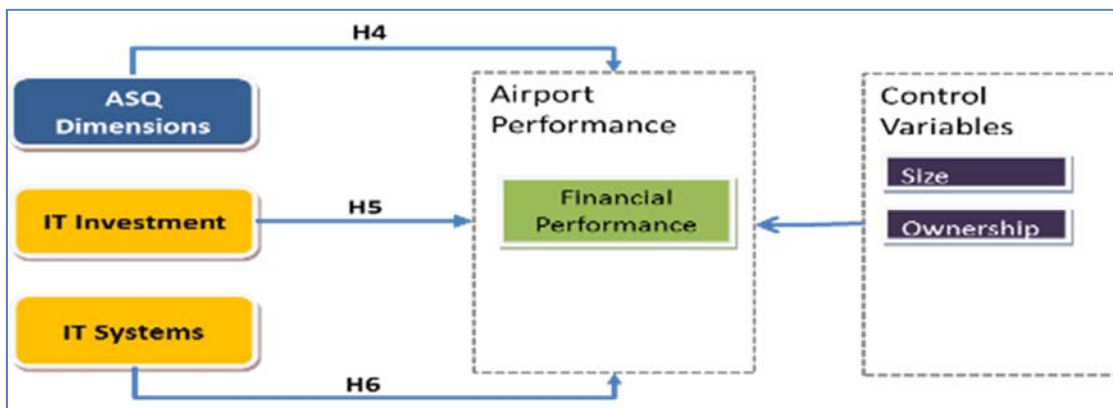


Figure 18. Research hypotheses (part 2 of 2).

H4a: There is a relationship between ASQ dimensions and airport performance

H4b: There is a difference in airport performance based on the use of ASQ

H5: There is a relationship between IT investment and airport performance

H6: There is a relationship between selected IT systems and airport performance

The hypotheses related to Airport Service Quality (ASQ) dimensions were included later in the study, as result of the face-to-face interviews of the airport case studies because the interviewees showed the use of ASQ as a tool to measure airport performance. These hypotheses were included to determine the relationship between ASQ and airport performance and whether there is a difference in performance between airports that use ASQ versus airports that don't use ASQ to measure airport performance.

A detailed explanation of each hypothesis is presented below in the context of the research questions.

### **3.2.1 Is there an association between IT culture and airport performance?**

One of the objectives of this research is to determine how IT is positioned in airports; the question of the importance of IT was discussed in Section 2.4 of the Literature Review.

The review highlighted different opinions on the relevance of IT. The five arguments presented by McFarlan and Nolan (2003) that IT does matter was used to develop the survey questionnaire. These five arguments were grouped under a single question to determine the benefits of technology, which are defined as: to show the potential of IT to gain competitive advantage (transformational benefit); to determine the associated economic benefits (i.e. cost reduction); to gain insight into the business and its customers, enabling the provision of more customer-centric services (i.e. Business Intelligence benefits); to differentiate products and services (i.e. differentiation); and to introduce new technologies to support the business (i.e. innovation).

The other aspects of IT are the role IT plays in business and its importance, or IT's relevance to airports. These two aspects of IT were addressed in two

separate questions (i.e. role and importance) The role of IT aims to determine whether IT plays a strategic role (i.e. is active in defining an airport's strategic goals); an operational role (i.e. is focused on improving the operational efficiency of an airport); a custodian role (i.e. is responsible for all IT matters of an airport); and transformational role (i.e. is changing processes with the introduction of new technologies or innovations).

“Importance” relates to the mission-critical nature of certain technologies or systems (e.g. baggage handling system, which due to a failure in the system caused a major disruption at the opening of Heathrow Terminal 5), the key to an airport's growth, to enhance products and services, to address the technology needs of an airport and to enhance the performance of an airport.

The review of IT-related literature incorporates a wide spectrum of its benefits (Kim and Jee (2007); Lin (2009); Jurison (1996)); the role of IT (Andersen (2001); Dewett and Jones (2001); Gregor et al. (2006); Huang et al. (2012)); and the importance of IT (Raschke (2010); Alam and Shahiduzzaman (2013)), but none in within the context of the airport industry.

The closest research that is specific to the airport industry is an annual survey that has been carried out by SITA since 2003, and whose primary focus is on the year-on-year spend and key investment priorities.

Instead of testing the relationship between these elements and airport performance individually, it was decided to group them as the IT culture of an airport. The reason is based on what Kotter (2008) defined in corporate culture as shared values (i.e. the sharing of important concerns and goals) by most of employees in the organisation; corporate culture is also one the elements identified by Kotter to influence an organisation's management behaviour. Shared values mean an airport as a whole will share similar views on the role, importance and benefits of IT. Therefore, IT culture has been adapted from a study from Gallivan and Srite (2005) as shared values, beliefs and norms regarding IT and its adoption.

The description of the elements that make up the role, importance and benefits of IT are similar and are tested as the IT culture. Therefore, IT culture hypotheses state that:

H1. There is a relationship between IT culture and airport performance

The expected results of the hypothesis testing is that factors of IT culture (i.e. role played by IT, the importance of IT, and the benefits of IT) have a positive impact on the performance of an airport.

### **3.2.2 What are the important airport IT characteristics that are associated with airport performance?**

Section 2.1 of the literature review describes four characteristics of an airport:

- Ownership
- Management (i.e. the use of Service Level Agreements as a tool to measure performance)
- Resources (i.e. use of outsourcing to mobilise resources)
- Competitive environment

The different types of ownership structures are one of the airport characteristics that has been the subject of several researches related to airport performance benchmarking.

The first characteristic is ownership. Oum et al (2006) and Oum et al. (2008) provide evidence that private airports or majority private airports achieve higher operating profit margins than publicly owned airports. Vogel (2006) shows that private airports are more cost efficient than publicly owned airports. These researches demonstrate that there is a relationship between ownership and performance.

The second characteristic focuses on management preferences, which in this case is related to the use of Service Level Agreements to measure performance. The complexity of managing different stakeholders to deliver services to airlines and to passengers creates the requirement to measure how these services are delivered (i.e. established Level of Service (LoS)).

IATA incorporated in its Airport Development Reference Manual (ADRM) the notion of Level of Services, but this is solely related to physical space. In collaboration with ACI, the latest release of the manual (2014), in addition to the physical space, incorporates processing and waiting times.

To address the needs of airport members and their business partners, in 2014 ACI Europe published the Guidelines for Passenger Services at European Airports, a framework to guide airport owners, operators and regulators to define a service level framework that takes into account passenger flow demand, spatial requirements and expected process rates.

Two important aspects of SLA are the ability to monitor performance and development triggers (i.e. areas for improvement) to deliver a consistent level of services.

The third characteristic is resources and the use of outsourcing to mobilise skilled and unskilled resources to deliver services. Oum and Yu (2004) examined the relationship between outsourcing and airport productivity and operational efficiency, with results indicating that airports that partially or fully outsourced terminal operations performed better than airports that did not outsource.

One example of outsourcing specifically linked to IT was the outsourcing of the entire IT department of Dusseldorf Airport to SITA in 2005. According to SITA, in the first five years of the outsourcing, Dusseldorf Airport enjoyed a 12% cost reduction year on year, despite the increase of passenger growth. This exemplifies the correlation between outsourcing and airport's financial performance. The study by Tovar and Martin-Cejas (2009) demonstrated similar results on the association between outsourcing and the efficiency of Spanish airports.

The fourth characteristic is the competitive environment, and it is clear that airports compete against each other, particularly when there is an overlap in the catchment area (e.g. Heathrow and Gatwick). According to Yuen and Zhang (2008) *“there is some evidence suggesting that airports with more competition are more efficient than their counterparts”*.

The four characteristics described above (ownership, management, resources, and competitive environment) are tested to determine their relationship to IT culture, as well as airport performance. In addition, the differences in IT culture based on different ownership structures are explored. The hypotheses being tested are:

H2a: There is a relationship between management preferences (SLA) and IT culture

H2b1: There is a relationship between ownership structure and IT culture

H2b2: There are differences in IT culture based on different ownership structures

H2c: There is a relationship between outsourcing and IT culture

H2d: There is a relationship between competition intensity and IT culture

H3: There is a relationship between airport performance and airport characteristics

### **3.2.3 What are the Airport Service Quality dimensions that are associated with airport performance?**

During the face-to-face interviews that were carried out to validate the questionnaire, the use of ASQ was mentioned as one way in which to measure operational performance, particularly from the passengers' satisfaction perspective, as the passenger navigates through the airport at different touchpoints (e.g. check-in, security, way finding, facilities, access, arrival, and the airport environment) provide a powerful tool for airports to measure their service performance.

The focus on passenger satisfaction is not purely from an operations perspective, but according to JD Powers (2008) the study of Passenger Satisfaction in North America finds that satisfied (delighted) customers spend 45% more at the airport than those who are not satisfied (disappointed).

A study from DKMA (2014) on airport service quality impacts on airport revenues shows a positive 0.1 increase in the overall passenger satisfaction compared to



the previous year (on five-point scale), results in a US\$0.8 increase in non-aeronautical revenues per enplaned passenger.

Therefore, the hypotheses are:

H4a: There is a relationship between ASQ dimensions and airport performance

H4b: There is a difference in airport performance based on the use of ASQ

Based on the interviews with four different airports, which were described in the Case Studies sections of the thesis, showed that those four airports were using ASQ to measure airport performance. However, the ASQ benchmark is also used by airport to improve operational areas, and as described in the DKMA study, the improvement in their ASQ scores can also lead to an increase in non-aeronautical revenue. Therefore, the hypothesis testing is expected to show a positive relationship between ASQ and Airport Performance, and that airports using ASQ have perform better than those who do not use them.

### **3.2.4 Is investment in IT associated with airport performance?**

The airport industry is relatively new with regards to studies related to IT in general and its relationship to performance. However, other industries have provided a reference to the relationship between IT investments and a firm's performance.

As discussed in Subsection 2.3.2, there is evidence that IT investments have a positive impact on firm's performance (Bharadwaj et al., 1997); and the results from the research from Hu and Quan (2005) suggested that a significantly positive relationship between IT investments and productivity; and Kim and Jee (2007)) concluded in their research that IT investment indirectly influence business performance as result of the strategic use of IT.

Studies, as shown above, demonstrated the relationship between IT investment and a firm's performance, but a firm's competitiveness can also be associated with IT investments through improved productivity (Mata et al., 1995), and operational efficiency and productivity (Brynjolfsson and Hitt, 1995).

Therefore, to determine the importance of IT investment and its association with airport performance, the following hypothesis is being tested:

H5: IT investment is associated with airport performance
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### **3.2.5 What are the IT systems that are associated with airport performance?**

Hypothesis 5 is testing the relationship between IT investments and airport performance, and now this question addresses ubiquitous airport systems that potentially will have an association with airport performance.

Certain IT systems have been shown to have improved performance based on marketing literature provided by suppliers. For example, shared infrastructure solutions such as CUTE (Common Use Terminal Equipment) and CUSS (Common Use Self-Service) enable airports to provide check-in desks and gates as a shared infrastructure, which means any airline can use them without having to bring in their own equipment (e.g. desktop computers to access its DCS hosts, boarding pass printers, baggage tag printers, and boarding gate readers). A shared infrastructure also enables airports to allocate check-in desks positions to suit their operational needs, which is particularly useful in the case of disruption, because they are not dedicated to a specific airline. According to SITA (2012), the operational impact is the increased processing capacity of the terminal; for example, an airport with a shared check-in infrastructure (i.e. CUTE and CUSS) can on average deliver 50% savings in terminal space. In Brazil, SITA estimated airport savings of 75%, because without CUTE the airport would have required an additional 108 positions to the existing 140, in order to meet the check-in requirements of new airlines. In the case of CUSS, in a scenario of 10 kiosks and six dedicated bag drop counters, it can handle approximately 300 passengers per hour compared to 108-120 passengers per hour handled in six counters.

The other is Resource Management System (RMS), a system used by airports for planning, scheduling and managing the fixed resources of an airport (e.g. gates, parking stands, check-in desks and baggage carousels). It is estimated that an RMS system can provide an airport with 25% better utilisation of

resources as result of better planning and dynamic allocation of resources. The Airport Operational Database (AODB) is a central database that allows airport operators to access operational data in real time, as well as distributing data. For example, the arrival of a flight is delayed, resulting in a new arrival time. The new arrival time is automatically received and fed into the AODB, which in turn automatically updates all the other systems that are integrated with the AODB (i.e. RMS will automatically re-allocate a new parking and gate position, the Flight Information Display System (FIDS) system updates the flight screens with information on the delay and the new departure time). The real-time exchange has an impact on the day-to-day operations of an airport, and equally important is that with the real-time and accurate information of a flight, the system automatically updates the airport's billing system, improving billing accuracy, and that reduces revenue leakages. Every airport has a Flight Information Display Systems (FIDS), a system used by airports to provide flight information such as check-in desks, gates and flight status (on time or delayed). In addition to providing flight status, the system can also be used as signage to improve passenger flow. More recently, FIDS screens have also been used by airports for advertising, enabling the generation of non-aeronautical revenues.

An airport cannot operate without Automated Baggage Handling, a system with automated conveyor belts that deliver baggage from the check-in to the area where it is loaded onto a container. Whereas the Baggage Reconciliation System (BRS) (i.e. to ensure that passenger and baggage are transported on the same flight) the reconciliation can be a manual or automated process. However, the automated system benefits airlines by reducing the number of mishandled bags, because on average a mishandled bag costs them US\$100 per bag (SITA, 2013), and benefits airports ensures a higher passenger satisfaction. The last system is Airport Collaborative Decision Making (A-CDM<sup>19</sup>), a platform where key stakeholders share information in real time to make fast operational decisions in

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<sup>19</sup> According to Eurcontrol: “A-CDM integrates processes and systems aiming at improving the overall efficiency of operations at European airports. Particularly focusing on the aircraft turn-around and pre-departure sequencing process”.

a coordinated manner, with minimum disruption to operations. The participation and involvement of Air Traffic Control is important, as it relates to optimisation of aircraft movements and ground resources. The expected benefits of an A-CDM solution are improvements in ATC Flow and Capacity Management by reducing delays, improving punctuality and optimising resource utilisation, which in some cases enables airports to handle an additional two to three movements during peaks hours, and airlines can also benefit from reduced fuel costs

Therefore, to determine which of the IT systems has a relationship with airport performance, the following hypothesis is being tested:

H6: There is a relationship between the selected IT systems and airport performance

### **3.3 Measurement issues: financial performance indicator**

This research defines airport performance as a systematic and iterative approach to ensure that an airport's objectives are consistently met by focusing on key areas: safety and security, service quality, productivity/efficiency, financial, and environmental. A range of performance measures were considered during the design of the questionnaire that specifically linked IT solutions and their impact on performance. For example, the interviewees were asked about the reduction in turnaround time by deploying solutions such as Self-Service, Resource Management System (RMS), A-CDM, and Airport Management System but these questions have been dropped because the difficulty the interviewees had in providing information about the performance measures for these systems.

There are number of performance measures that have been described in publications from ACI, ICAO and ACRP 19A, which are used for different purposes and by a number of different stakeholders (Humphreys, Francis and Fry, 2002). And in order to test the hypotheses shown above, the airport performance measure being tested is a financial performance measure of the total revenue per aircraft movements (REV\_MVT). There are other financial indicators, such as aeronautical revenue per passenger, aeronautical revenue

per movements or total revenue per employees, which are described in Table 25 in Appendix A.

However, the Total Revenue per Aircraft Movement (REV\_MVT) was chosen for the following reasons:

The total revenue of an airport is derived from both aeronautical and non-aeronautical revenues where aeronautical revenues are generated from aviation related activities such as landing fees, passenger or terminal charges with a significant portion of an airport's activity being related to aircraft movement (Air Transport Research Society (ATRS), 2015). Thus, making aircraft movements an important operational indicator of an airport.

One of the main challenges for researchers is to obtain the split between aeronautical and non-aeronautical revenues. Information can be found in published annual reports that are available in the public domain. However, many airports do not publish their accounts. As stated by Zenglein and Muller (2007), even when financial data is available the following data consistency and quality issues need to be resolved:

- i. A lack of consistency in data reporting with varying levels of aggregation / granularity. Despite the data availability, there were inconsistencies in the reporting of the revenue data, which in some cases involved an aggregated value of aeronautical and non-aeronautical revenues
- ii. Differences in the level of financial disclosure transparency which is generally due to different ownership structures where listed companies are required to provide more detailed financial data than non-listed airports
- iii. The challenge of comparing multiple airport groups with single operators
- iv. A lack of consistency between reporting years

For the purposes of this research the Total Revenue of an airport was considered, which includes both aeronautical and non-aeronautical revenues.

Most performance indicators used core indicators (e.g. total annual number of passengers or total annual number of aircraft movements) as denominators; for example, aeronautical revenue per passenger or aircraft movements per gate:

- i. Passengers: a core indicator is applicable to commercial service airports and is driven by demand, route and pricing.
- ii. Movements: a core indicator is applicable to all airports and is driven by demand, route and pricing.

It can be argued that aircraft movement is not ideal because it does not take into account the different types and sizes of aircraft but it is an important indicator to measure airfield operations performance (Graham, 2005). Similarly it can be argued that the total passengers does not take into account the different segments (i.e. domestic versus international), where there will be different effects on airport costs and efficiency. According to Gillen and Lall (1997), the share of international passengers has a significant impact on the efficiency of the airport. However, both passengers and aircraft movements are considered core performance indicators in the ACI Guide to Airport Performance Measures (ACI, 2012) as well as being used as an indicator in measuring airport economic performance (ICAO, 2013). And for the purposes of this research, the aircraft movement was chosen because it reflects the performance of both airside and terminal operations, and the technology deployed by airports is expected to improve not only the passenger and baggage processing but also airfield operations as well.

Lin and Hong (2006) demonstrated that to increase operational performance (i.e. efficiency) of a hub airport, a higher level of movements is required. However, the increase in movements (i.e. frequency) is outside the control of airports but instead is under control of airlines. And in period of growth in demand, airlines tend to increase frequencies than increase aircraft size (Givoni and Rietveld, 2009). However, there is a specific procedure set out by IATA in their Worldwide Slot Management Guidelines (IATA, 2014), where airport stakeholders negotiate the number of movements (i.e. arrival and

departing) per hour to avoid congestion and facilitate the slot allocation (Liebert, 2011).

A study of demand and capacity management by Barnhart, Fearing, Odoni and Vaze (2012) showed that “any reduction in capacity (as measured by the number of aircraft movements per hour) occasioned by the increased presence of larger aircraft in the fleet mix will be slight relative to the resulting increase in the number of seats the airport can process per hour”. So this research assumes that the recorded aircraft movement by airports is representative of the airlines adjustments to meet their operational objectives.

To summarise aircraft movements was selected as the denominator for the following reasons:

- i. Aircraft movements impact other performance indicators such as those related to operational performance (e.g. runway utilisation (aircraft movements per runways), and terminal utilisation (aircraft movements per gates) or quality of services (e.g. delays).
- ii. Aircraft movements is one indicator that shows the airport’s ability to generate revenues.
- iii. ATRS (2015) have movement-base performance measures such as aeronautical revenue per aircraft movement, total operating (net operating income) revenue per aircraft movement, as well as productivity indicators (e.g. aircraft movements per employee, and aircraft movements per runways).
- iv. Airports Council International (ACI) in their Airport Economics Report (2013, and 2014) reports the financial performance of airports by using total airport revenue per aircraft movement, total operating revenue per aircraft movement, operating aeronautical revenue per aircraft movement, operating non-aeronautical revenue per aircraft movement, and non-operating revenue per aircraft movement.

Therefore, for the above reasons the chosen performance indicator is Total Revenue per Aircraft Movements, which is now reported in the ACI Airport Economics Report.



## 4 METHODOLOGY

This chapter describes the proposed methodology or research framework to be undertaken.

### 4.1 Research strategy – choice of methodology

Prior to choosing a methodology, the most common forms of research methodology used in the Management of Information Systems were identified, as the subject of this research is to assess the relationship between IT and airport performance. The selection of a methodology for a research project is *“critical to the resulting quality and value of the project. The selection of the best methodology must be determined within the context of the research objective”* (Jenkins, 1985). Jenkins compared several research methods applicable in the field of Management of Information Systems, using several criteria such as results (qualitative or quantitative), reliability (i.e. repeatability of the research), and the variables (i.e. strength of the independent variable, magnitude of the variables, and potential of manipulation of the independent variable).

The research methods identified with the potential of being used in this research are the survey, case studies, maths modelling, free simulation, and field experiment, which are briefly described as follows:

Survey: With this methodology, information is gathered through interviews or questionnaires, and with the responses test hypotheses. With this methodology, there is a potential to manipulate the Independent Variable, and reliability is medium to high. This methodology generates quantitative results.

Case study: In this methodology, subjects or entities are studied without interference from the researcher, and the variables are neither controlled nor measured. The reliability of this type of research is low. This methodology generates qualitative results.

Maths modelling: This a closed methodology, because both the independent and dependent variables are known, and the results are expressed as a mathematical

formulation. The reliability of this method is high. This methodology generates quantitative results.

Experimental simulation: In this methodology, individuals are used to test applications in a controlled setting, with high potential to manipulate the independent variable. The reliability of this method is medium to high. This methodology generates quantitative results.

Free simulation: This methodology is similar to the experimental simulation, in which individuals are used to test applications in a controlled setting. However, their timing is determined by the researcher and individuals. The potential to manipulate the independent variable is high, whilst its reliability is low to medium. This methodology generates quantitative results.

The most significant and important step to determine the research method is the definition of the research theme, which in this case is the assessment of the relationship between IT and airport performance. Therefore, three of the methodologies described are discarded. Two methodologies (i.e. experimental simulation and free simulation) are discarded because no systems are being tested as part of this research, and the third (i.e. maths modelling) is discarded because the objective is to assess a relationship but not to quantify it.

The proposed methodology for this research is a multi-method approach, which uses both qualitative and quantitative data that are treated as separate data sets. Therefore, the case study methodology and survey methodology are used in this research.

## **4.2 Case study methodology**

The case study methodology is defined as an “*empirical inquiry investigating contemporary (i.e. not a historical event) phenomenon in-depth and within its real-life context*” (Yin, 2009). The results of this methodology is expected to provide an insight into how IT is perceived by airports and whether it has an impact on airport performance.

The case study methodology followed three steps: (a) design to ensure quality of the research; (b) data collection; (c) data analysis. They are described as follows:

Design: the design of the case study has to have as the main objective, the design quality, and Yin (2009, p. 43) provides four tests:

Construction validity: identify the correct operational measures, preferably using published studies

Internal validity: establish a causal relationship, mainly concerning explanatory case studies

External validity: identify which parts of the case study's findings can be generalised

Reliability: demonstrate that the procedures (e.g. data collection) can be repeated and arrive at the same results

Data collection: there are six sources of data for case studies (Yin, 2009): documents, archival records, interviews, direct observations, participant observations, and physical artefacts<sup>20</sup>.

Analysis: the two steps in data analysis are data preparation and qualitative data analysis. As part of the data preparation, there are three aspects to be considered: data storage – as case studies can use multiple sources of data (e.g. recordings, images and texts), it is essential to have proper data storage of these sources; transcribed interviews; and data cleaning, which in addition to ensuring there is a proper coding system, takes into account confidentiality and anonymity (Wahyuni, 2012). According to Boeije (2010), data analysis is about forming meaningful findings from data that has been pulled apart and reassembled, and for this a coding system is applied. Today there are various computer-assisted qualitative data analysis software (CAQDAS) packages, such as NVivo, Atlas.ti

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<sup>20</sup> Yin defines physical artefact as a “*work of art, tool or instrument or some other form of physical evidence*” and it is extensively used in anthropological studies”.

and MAXqda. However, according to Welsh (2002), better results are likely to be achieved with a combination of both manual and computer-assisted methods.

The case study methodology principles described above are applied to analyse and present the results of interviews of 16 people representing four airports as part of the validation of the survey questionnaire, which is described in Section 4.5. The interviews generated qualitative data that required a different approach to analyse the data.

#### **4.2.1 The airport performance case study methodology**

Two case studies are presented in this research, the first specific to the pilot airport, and the second case study is about three participating airports. For reasons of confidentiality and anonymity, the names of the airports and the interviewees are omitted but coded for ease of reference. For example, the pilot airport is referred to Airport A, and one of the interviewees as CIO.

To ensure the design quality of the case studies, the following steps were taken: external validity (extensive description of the airports – ensuring anonymity – is provided to enhance external validity); internal validity (there has been careful selection of the airports, which enhances the credibility of the case studies); and reliability (a detailed explanation of the steps and tools used is provided; e.g. interview questionnaire).

The data collection method chosen for this research is the interviews, using the same questionnaire as that in the survey methodology. Details of the questionnaire design and validation is given in Section 4.4.

For the data analysis, there has been a mixed approach that uses manual analysis, because there are only 16 interviews. A software application, Nvivo<sup>21</sup>,

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<sup>21</sup> NVivo is a data analysis software application that helps to “organise, analyse and visualise information. Users can organise their material by topic, and uncover trends and emerging themes”.  
[http://techcenter.qsrinternational.com/techcenter.htm#nv10/nv10\\_extending\\_a\\_license.htm](http://techcenter.qsrinternational.com/techcenter.htm#nv10/nv10_extending_a_license.htm)

has been used mainly to edit and review the transcribed interviews, and to provide word frequencies to find patterns in the data.

#### 4.2.1.1 Data analysis using NVivo

The main data sources are the 12 transcribed interviews, because the pilot airport interviewees requested interviews not to be recorded. In addition to the transcribed interviews, interview notes and audio files were imported into NVivo, which is shown in Figure 19.

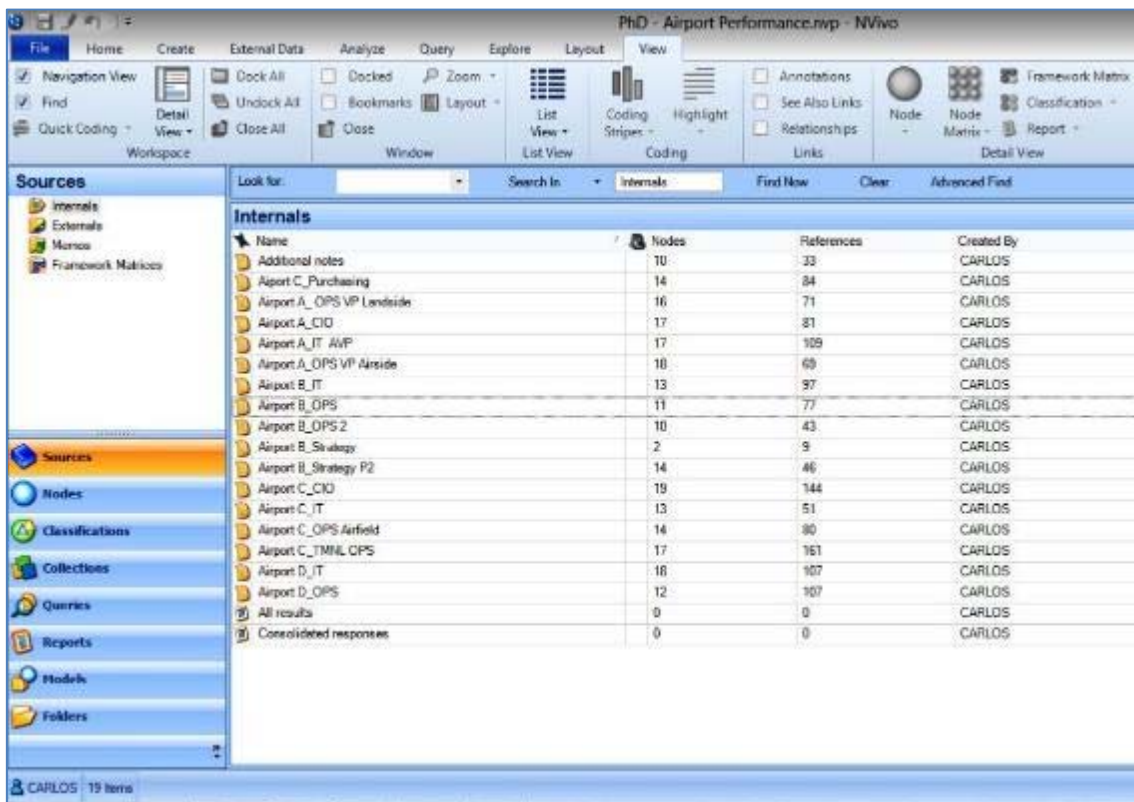
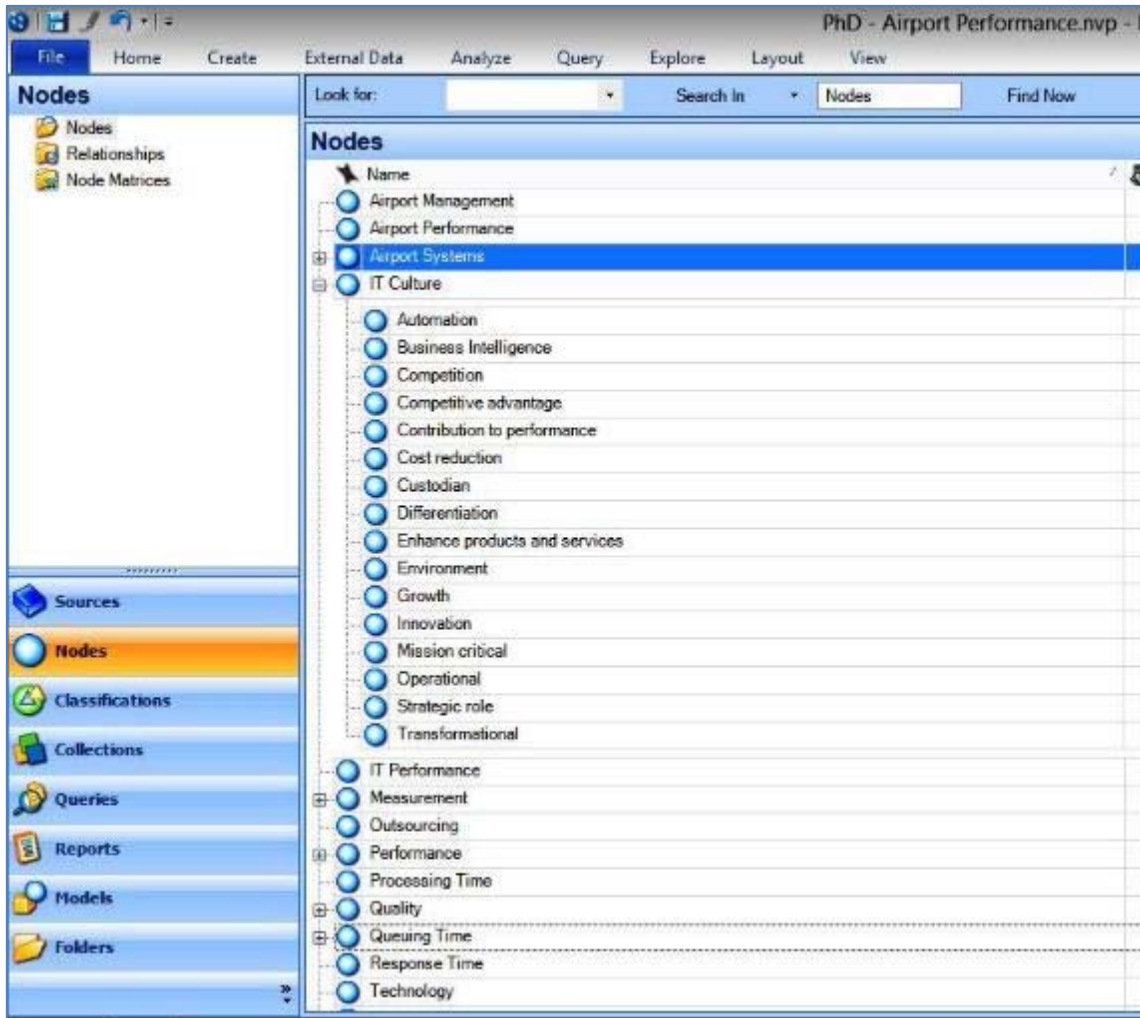


Figure 19. NVivo – imported data sources.

Coding is central to analysing data in qualitative research, and it refers to breaking the data down into manageable pieces (Welsh, 2002) and gathering them as a specific topic or theme, which is referred to as a node in NVivo. A screen shot of the NVivo nodes used in this research is shown in Figure 20.



**Figure 20. NVivo nodes used in this research.**

NVivo's Query Wizard was the most useful feature of the tool, because it quickly searched for frequencies of specific words or sentences. For example, under the node "Airport Performance" and a specific query for "high impact on airport performance" generates frequencies and references that can be further explored to assist in the analysis.

NVivo, as computer-assisted data analysis software, is a tool that facilitates organisation and data analysis. For this research, it is used as a framework to code the transcribed interviews and to enable quick data visualisation (e.g. frequencies, patterns and relationships).

### **4.3 Survey methodology**

The author also researched the literature on the most common type of research methodologies used in the field of Management of Information Systems. The result of the review, two studies are important to mention. The first is “Research Methodologies in MIS: An Update” (2004), which provides a report on research themes and research methodologies based on an examination of all articles published by MIS journals for the period of 1993 to 2003. As the title article indicates, it is an update of an earlier work that covered a period from 1993 to 1997. The key finding of this research is that during this period the highest-ranking methodology used was survey, followed by Frameworks/Conceptual Models, and Laboratory Experiments. The second study is “A Methodological Examination of MIS Survey Research from 1992–2006” (2009) the researchers’ objectives for this study was to provide an insight on the most-used methodology by analysing publications of three journals. Their research showed that the most-used methodology is also survey.

This research project also requires specific airport data in order to demonstrate whether a relationship between IT and airport performance exists, and the best suited methodology is the survey. The survey has other advantages over different methodologies – it is very cost-effective (Wiggins and Stevens, 1999) compared to other types of investigations.

In the airport industry, the survey methodology was used by Francis et al. (2002), in which questionnaires were sent to the 200 busiest airports in the world, along with a pilot survey, before the release of the survey globally. In addition to the questionnaire survey, face-to-face interviews were carried out with selected airport managers in Europe to collect additional data. An important fact was the need to provide the interviewees with a strict anonymity clause.

The global survey questionnaire was sent out with two additional mailings within a period of three months (i.e. August to November) to account for wrong addresses or undelivered mail. Finally, 195 surveys were delivered, four declined to participate, 58 responded and there was a 32% response rate.

Halpern (2006) used the questionnaire-based survey sent to 217 airport managers across 17 countries in Europe. The survey had a response rate of 40% (i.e. 86 usable responses).

ACI North America (ACI NA) for the past eight years has been producing financial benchmarking and uses a survey to collect data from airport members. One advantage that ACI NA has is that airports can use the survey to produce a report required by the FAA, thus increasing its response rate.

ACI World annually produces an economic report with key performance indicators. The methodology used by ACI is the survey, which in 2013 received a total response from 653 airports. The sampling objectives of the survey were: (1) maximise participation and coverage (208 airports in Europe, 185 airports in Latin America and Caribbean, and 104 airports in Asia Pacific) in terms of passenger and cargo volume; (2) provide analytical variation and rigour by encouraging participation of airports with lower traffic volume; and (3) provide a regional as well as global view of the airport industry.

Other organisations, such as service providers to the industry, including SITA, also use survey methodologies to obtain information from airports and airlines to generate the reports: Airport IT Trends, Airline IT Trends, Passenger Self-service and the Baggage Report.

Therefore, the chosen methodology for this research was the survey.

#### **4.3.1 Selection of the internet or online survey**

The next step in the methodology is to determine how the information will be collected; that is, how the responses to the questionnaire will be sent and received.

The face-to-face interviews methodology for data collection has long been considered one of the dominant methodologies in qualitative research (Opdenakker, 2006). It is considered that face-to-face interviews produce high-quality data because of the intervention of the interviewer (Bayart, C. and Bonnel, P., 2012). The presence of the interviewer is an important element, because they



can explain the purpose of the research and the interviewee's role, and explain a question more clearly should an answer given be considered inadequate (de Leeuw et al., 2008).

Despite the advantages that the face-to-face interview brings in terms of data quality, as a data collection methodology it was not considered an option for this research for the following reasons:

- a) the airport population of this study is very large and spread over different regions: Americas, Europe, Middle East and Africa, and Asia Pacific;
- b) costs related to travel and other expenditures to conduct face-to-face interviews or even via the telephone; and
- c) time due to the logistics of scheduling interviews; even in the case of online interviews, scheduling across different time zones

Mail surveys are self-administered surveys that are frequently used to reach a large population and are considered less expensive than interviews (face-to-face or telephone interviews). However, with the advance in communication and technology, internet (online) surveys are gaining popularity (de Leeuw et al., 2008).

A study by Shih and Fan (2007) examined the results of 35 study results within a 10-year period and compared the response rates between mail and email surveys. Their conclusion was that mail surveys provided higher response rates than email surveys (on average, the response rate for email surveys was 20% lower), with the exception of the college population where the results were negligible.

However, in another study, Baruch and Holtom (2008) examined over 1,600 published papers between 2000 and 2005 that consisted of over 100,000 organisations and 400,000 respondents to conclude that electronic surveys (e.g. online, email and phone) resulted in high or higher response rates than mail surveys.

The difference in response rates between internet (online) and mail surveys may be explained by different factors, such as differences in methodology,

procedures, samples, and penetration of internet. However, Barrios et al. (2011), in their study of the response rate and data quality, indicated that “topic salience” (i.e. the importance of the subject to the respondent) had an impact on response rate. In addition, their study showed that online surveys had a higher response rate than mail surveys and were of a higher quality with fewer errors and missing items.

Therefore, from a methodology perspective, and for the purposes of this research, the chosen methodology is the internet (online) survey. The methodology is shown in Figure 21, and each step is described in more detail in the following subsections of this chapter.

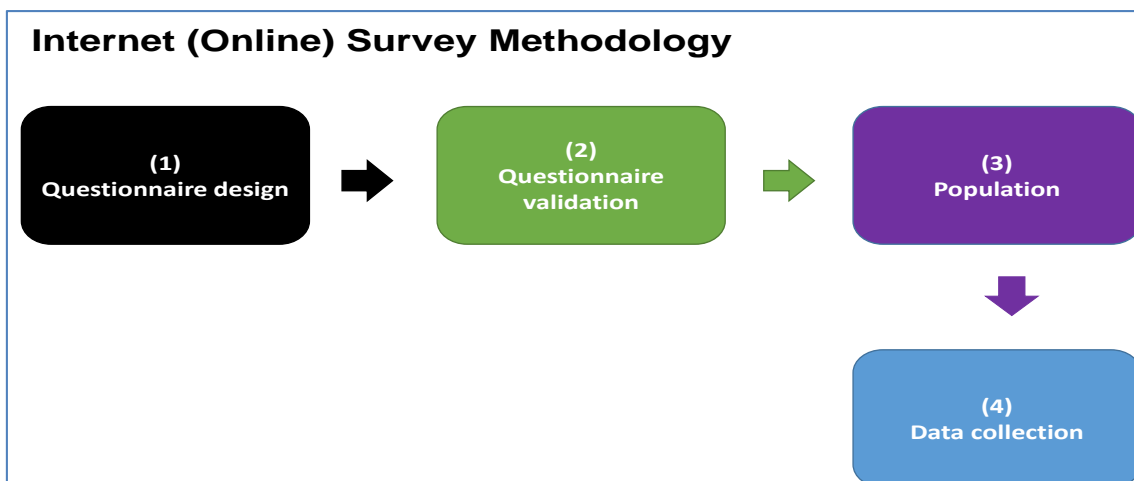


Figure 21. Internet (Online) survey methodology.

#### 4.4 Questionnaire design

This section describes how the data is to be collected using a survey questionnaire; the design of the questionnaire is an important step, because a poor design will result in useless data. Therefore, the questionnaire needs to ask clear, precise and unambiguous questions to produce meaningful results, particularly so in case of self-administered surveys.

Based on the literature review (Chapter 2), the following questions need to be answered:

- 1) Does IT culture have an impact on airport performance?
- 2) What are the airport characteristics that impact airport performance?

- 3) What is the airport's IT intensity?
- 4) What are the IT systems that have an impact on airport performance?

These questions formed the foundation on which to build the questionnaire used in this research.

#### **4.4.1 The questionnaire**

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The questionnaire evolved and was improved with new questions added and others being removed. The changes were results of the face-to-face interviews of Stage 2 (i.e. validation of the questionnaire) of the survey methodology illustrated in Figure 21.

A framework with four principles was developed in the creation of the questions:

- 1) Type of questions: determine the mix of open and closed questions.
- 2) Constructs<sup>22</sup>: ensure the questions are meaningful within the context of this research, which means ensuring alignment with the aims and objectives of the research.
- 3) The right question: ensure the respondent understands the question and is able to provide an answer.
- 4) Reduce ambiguity: The aim of the questionnaire is that it is going to be a self-administered online survey targeting different nationalities. In the context of the research, ambiguity may arise when two respondents may interpret the same question in two ways, and their responses do not reflect that they wanted to say something different. Therefore, to reduce ambiguity, the choice of words had to be carefully considered, thus minimising the use of technical words, jargon and acronyms.

The original questionnaire, which can be found in the Appendix C, was divided into two parts: (1) Role of IT and (2) IT intensity of the Airport. Under these two parts, a total of 36 questions were created.

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<sup>22</sup> Cronbach and Meehl (1955) define a hypothetical construct as the concept of a single event that cannot be directly observed, but instead refers to "*groups of functionally related behaviors, attitudes, processes, and experiences*".

Under Role of IT, questions were created to establish (i) how IT is positioned in the airport by exploring the fit of IT in the airport organisational structure, the reporting line of the CIO and the procurement process of IT; (ii) the importance of IT (i.e. role and priority); (iii) how IT helps performance and its expected benefits to the organisation, such as bringing cost reductions to the airport; (iv) IT intensity by determining IT spend and key investment areas in IT; and (v) airport characteristics by understanding the airport's preferences regarding service levels, resources and the competitive environment.

#### 4.4.2 Types of questions

##### 4.4.2.1 Closed or closed-ended questions

Closed questions or closed-ended questions forces the respondent to choose an answer. These questions are used to determine frequencies and categories of responses, and in the questionnaire there are two types of closed-ended questions: multiple-choice and dichotomous (i.e. Yes or No answers).

**MULTIPLE CHOICE QUESTIONS** are used to get respondents to answer to either one question or choose from multiple answers. For example, in the original questionnaire shown in Figure 22 that the author was interested to have one response about the type of ownership.

7B. Airport Ownership:  Private  Public  Mixed  Corporatised

N.B.: Corporatised airport: allocation of the non-regulatory functions of the airport under a new airport company which will undertake the operational functions of managing the airport.

**Figure 22. Closed questions with multiple-choice questions with a single answer.**

In the case of online surveys such as that provided by SurveyMonkey, there are specific settings for closed questions with multiple choices. For example, SurveyMonkey uses radial buttons to obtain one answer from the respondents and check boxes to obtain multiple answers, as illustrated in Figure 23. Although it should be noted that SurveyMonkey allows for the single or multiple responses, but it must be chosen at the design stage of the questionnaire.

Single answer	Multiple answers
<p>1. What is your job role?</p> <p><input type="radio"/> Manager</p> <p><input type="radio"/> Senior Manager</p> <p><input type="radio"/> Regional Manager</p> <p><input type="radio"/> Vice President</p> <p><input type="radio"/> Management / C-Level</p> <p><input type="radio"/> Other</p>	<p>2. What are the IT solutions your airport is sourcing at present?</p> <p><input type="checkbox"/> Hardware</p> <p><input type="checkbox"/> Software</p> <p><input type="checkbox"/> Systems Integration</p> <p><input type="checkbox"/> Outsourcing</p> <p><input type="checkbox"/> All of the above</p>

**Figure 23. Closed questions multiple-choice questions with single and multiple answers.**

An important element when designing closed questions is that the “answers should be mutually exclusive and exhaustive”, according to Fowler and Cosenza (2008), who propose that there should one answer that best describes the respondent’s situation, and a response choice for all respondents. They illustrated a case of a questionnaire mistake (“are you married, separated, divorced, living with a partner, or never been married”) where the two concepts are mixed, in this case, the marital status versus living arrangements because a person could be divorced and be living with a partner.

However, it will not always be practical to list every possible option (exhaustive), so in these cases some of the questions have added the “Other” option and text box to qualify the response as shown in Figure 24.

**1. What is your functional role?**

Operations

IT

Finance & Administration

Commercial

Engineering

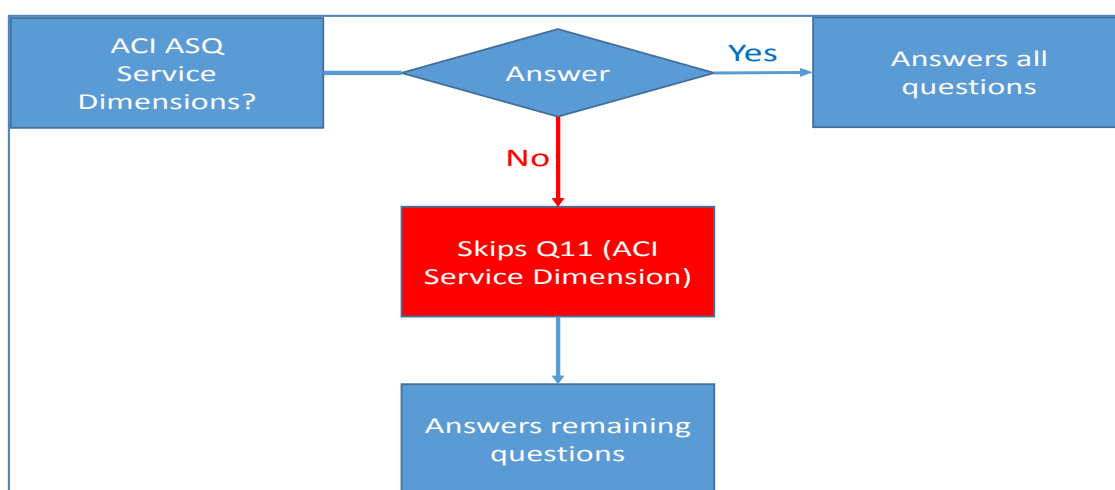
Legal

Other (please specify)

**Figure 24. Closed questions with additional answer.**

**DICHOTOMOUS QUESTIONS** are used as a filter that leads the respondent to another question. Therefore, there are only two possible answers to a question, for example responses such as “True or False” and “Yes or No”.

Online surveys enable filtering by taking the respondent to a specific section of the questionnaire, depending on the given answer. Figure 25 below illustrates the dichotomous questions and how the filtering is used; it is Question 10 of the online survey used in this research. The question is whether the airport uses ACI ASQ (Airports Council International Airport Service Quality) service dimensions to improve airport performance, and depending on the answer:



**Figure 25. Example of a dichotomous question.**

#### **4.4.2.2 Open or open-ended questions**

Open (or open-ended) questions do not offer answers from which the respondent can choose from, and are often used to gather qualitative data.

Open-ended questions were used in the questionnaire to gain insight regarding airports, as shown in Figure 26:

- a) The measures of airport performance, use of performance indicators and how they are related to IT
- b) The fit of IT in the organisational structure of the airport because, as Cohen and Toleman (2006) indicated, an organisation’s stronger commitment to IT positively impacts the performance of the organisation.

<b>3B. The measurement of IT performance.</b>
3B1. How do you measure IT performance?
3B2. How does the rest of the organisation measure IT performance
3B3. What are the KPIs used?
3B4. How these were determined?
<b>3C. The measurement of performance.</b>
3C1. Does the airport use other Performance Indicators? If yes, please indicate them.
3C2. How many are related to IT?
3C3. How are they related to IT?
3C4. Other comments
<b>4. Organisational fit.</b>
4 A. Where does IT fit in the organisational structure of the airport?
4B. Is IT a business unit on its own?
4C. Can you please provide a copy of the airport and IT org chart?
4D. Does the CIO report to the CEO? If not, to whom does the CIO report to?

**Figure 26. Open-ended questions.**

The challenge of open-ended questions in self-administered questionnaires is that the respondent has no one to turn to if they do not understand the questions, which may yield lower responses than closed-ended questions (Reja et al., 2003).

#### **4.4.2.3 SCALED QUESTIONS**

Scaled questions are used to measure a respondent's strength of opinions, rank order and preferences (e.g. very important to not at all important).

##### **Likert**

There are a number of scaled questions, but the commonly used ones are those by the Likert scale. The Likert scale consists of ordered categories that allow respondents to make a mark, indicating their response anywhere along a 5-point scale, as shown in Figure 27. As a result, a Likert scale-type question will provide data that are measured at an ordinal level.

<b>9A. Management:</b> Which of the following statements best describes your organisation?					
	5= Strongly agree	4 = Agree	3= Neither agree or disagree	2= Disagree	1= Strongly Disagree
Service levels are an important element by which to measure airport performance	<input type="checkbox"/> 5	<input type="checkbox"/> 4	<input type="checkbox"/> 3	<input type="checkbox"/> 2	<input type="checkbox"/> 1
IT solutions are procured to ensure service levels are maintained	<input type="checkbox"/> 5	<input type="checkbox"/> 4	<input type="checkbox"/> 3	<input type="checkbox"/> 2	<input type="checkbox"/> 1
There are Service Level Agreements relating to passenger processing time	<input type="checkbox"/> 5	<input type="checkbox"/> 4	<input type="checkbox"/> 3	<input type="checkbox"/> 2	<input type="checkbox"/> 1
There are Service Level Agreements relating to baggage processing time (first bag in and out)	<input type="checkbox"/> 5	<input type="checkbox"/> 4	<input type="checkbox"/> 3	<input type="checkbox"/> 2	<input type="checkbox"/> 1
There are Service Level Agreements relating to aircraft processing time	<input type="checkbox"/> 5	<input type="checkbox"/> 4	<input type="checkbox"/> 3	<input type="checkbox"/> 2	<input type="checkbox"/> 1

**Figure 27. Likert scale question.**

Figure 27 shows the question using an odd-numbers Likert scale, which can vary from three to 11 points, with the 5-point or 7-point scales being the more commonly used (Dawes, 2008). There are also even-numbers scales varying from two to 10 points. However, the key difference is that in odd-numbers scales there is a neutrality point, whilst in even-numbers scales the respondent is forced to choose to agree or disagree.

Likert 5-point scales tend to be worded scales, as shown in Figure 27, whilst scales with larger points tend to be numerical because *“the gradation of (dis)agreement on a 10-point rating scale probably becomes too fine to easily express in words”* (Dobronte, 2012).

Concerning the number of points of a Likert scale, Dawes (2008) concluded that the 5-point or 7-point scale produced slightly higher mean scores compared to those produced by a 10-point scale, and this difference was statistically significant. In terms of the other data characteristics, there was very little



difference among the scale formats in terms of variation about the mean, skewness or kurtosis.

The issue of the optimal number of response categories (i.e. points) has been argued with no conclusive agreement: Dillman et al. (2009) make a recommendation for four to five points, Sauro (2010) argues that a 7-point scale is “slightly better than 5-point”), and others recommend the use of a 9-point scale (e.g. Lee and Soutar, 2010). Pearse (2011) argues that scales with high levels of granularity (i.e. more points) may provide more accurate and reliable data. However, for this to happen, the level of granularity has to be meaningful to respondents. It is also argued that a questionnaire with large response points may make the questions more complicated, thus taking longer to be completed.

After the review of the optimal number of points of scaled questions, the decision was to create the questionnaire using the 5-point Likert scale because:

- a) it is a worded scale and more meaningful to the respondent
- b) it provides a neutral point
- c) for multiple questions the number of points matter less (Sauro, 2010)

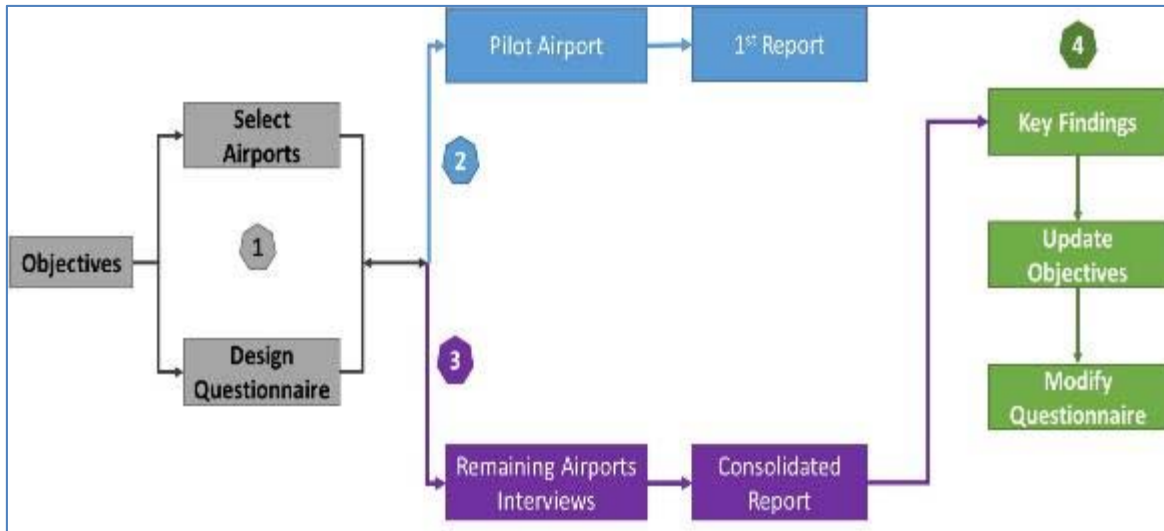
A copy of the original questionnaire can be found in the Appendix C of this document.

#### **4.5 Questionnaire validation**

With the questionnaire created using a mix of open-ended questions and closed-ended questions, including both dichotomous and scaled questions, the next step in the process was the validation (i.e. testing) of the questionnaire.

The testing of the questionnaire as summarised by de Leeuw (2008) “is the only way of assuring that the survey questions written, do indeed communicate to respondents as intended”.

The diagram in Figure 28 provides an overview of the four steps to validate the questionnaire.



**Figure 28. Four steps to validate the survey questionnaire.**

The five steps are described in the sections below.

#### **4.5.1 Step 1: Objectives – Questionnaire design– Target airports**

**Objectives & Questionnaire Design:** They refer to the drivers of this research, which is to establish the relationship between IT and airport performance. In order to establish the relationship, a number of questions have been formulated (e.g. What are the airport characteristics that impact airport performance?), and they form the basis of the questionnaire used in this research. The detail description of the design of the questionnaire is found in Section 3.2 of this report.

**Target Airports:** The selection of the airports were based on two main characteristics (i.e. type of ownership and geographical location) and information richness of each airport.

Four airports were selected and all of them have requested anonymity regarding the identification of the airport, as well as the identity of the respondents.

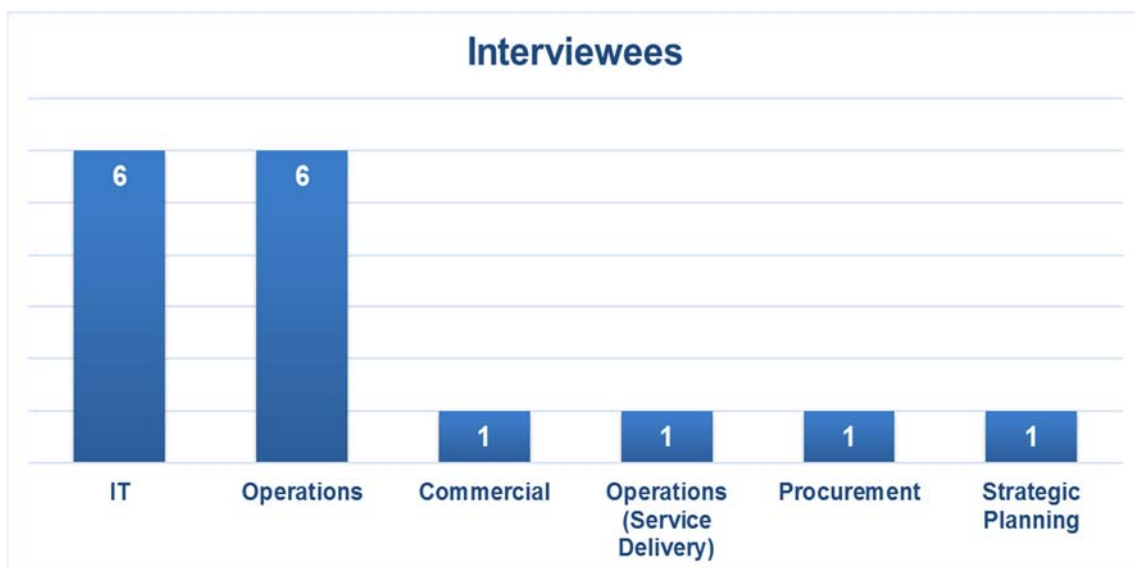
The airports are:

- Airport A: corporatised airport in Southeast Asia
- Airport B: corporatised airport in Northeast Asia
- Airport C: private airport in Australia
- Airport D: publicly owned and privately managed airport in Europe

**Target Functions:** Considering the objective of the research to establish the relationship between IT and airport performance, it was necessary to have a balanced view both from the IT department and airport operations.

Airport operations is one of the functions within an airport that relies on technology to deliver its services and meet its objectives. For example, airports should provide accurate and real-time information to passengers, such as check-in desks numbers, flight status, gate information, baggage claim information, and disruption information. And so the airport relies on technology to provide the information on multiple channels, such as Flight Information Display Systems, airport website and mobile applications.

The other key target is IT, because of its role in providing the information and technology requirements of the airport. However, during the setup, some of the airports suggested that additional functions be interviewed. Sixteen people in different functions were interviewed, as shown in Figure 29.



**Figure 29. Target Audience for the interviews to validate the questionnaire.**

#### **4.5.2 Step 2 – Pilot airport**

Discussion with Airport A (Southeast Asia) to get its involvement started on 17<sup>th</sup> October 2012, with the first interview taking place on 15<sup>th</sup> November 2012; the last two interviews were completed on 03<sup>rd</sup> December 2012. The four people interviewed are shown in the order in which they were interviewed:

- Assistant VP IT (IT AVP)
- Chief Information Officer (CIO)
- Vice President Terminal Operations (OPS VP – landside)
- Vice President Operations (Airside) (OPS VP – airside)

The interviews took place at the airport, with three of them being face-to-face interviews and the fourth one via Skype due to a schedule conflict. These interviews were not taped, and responses were written up for analyses.

The interviews provided an insight to how the airport measures performance and how they are related to IT. Detailed analysis of the pilot interviews are described in Chapter 4 of this report.

From a questionnaire testing perspective, three issues were identified, and these are described below.

- a) Intervention was required to explain the meaning of the questions, which would pose a problem in the actual roll-out of the self-administered survey, because it could potentially reduce reliability and validity.
- b) Question 6 (Figure 30 of the questionnaire related to four airport systems (e.g. self-service kiosks for check-in, Resource Management System, Airport Collaborative Decision Making (A-CDM), and airport management systems)) was too specific and complex, so that respondents were unable to provide answers to all questions.

6. Solution specific and its performance: (a) Self-Service   (b) Resource Mgmt Sys (RMS)   (c) A-CDM   (d) Airport Mgmt Sys (AMS)
6A. How much was invested on each of the above solutions? <i>Information could not be provided</i> Self-Service: <i>not available</i> RMS: <i>\$300k? no sure</i> A-CDM: <i>not implemented</i> AMS: <i>not available</i>
6B. What was the reduction in turnaround time by deploying the solutions above? Self-Service: <i>not measured</i> RMS: <i>the system does gate assignment but turnaround will depend on the activities of the ground handler</i> A-CDM: <i>not implemented - intuitively helps but unable to quantify</i> AMS: <i>not measured</i>
6C. What are the KPI set for these solutions? Self-Service: <i>not measured</i> RMS: <i>not measured</i> A-CDM: <i>not implemented</i> AMS: <i>not measured</i>
6D. Did other stakeholders (airlines, ground handlers, government agencies, etc) get involved in the procurement of the solution(s)? Please indicate the stakeholder. <i>Stakeholders were not directly involved in the procurement process. However, a consultation is carried out with them to ensure that their requirements are captured and how they could be included in the tender document. It is a collaborative effort but the decision rests with IT and/or Business Partner (e.g. Airport Operations).</i> Self-Service: RMS: A-CDM: AMS:
6E. Did other stakeholders (airlines, ground handlers, government agencies, etc) get involved in the decision process? Please indicate the stakeholder. <i>The stakeholders' input is taken into account during the decision process since the final decision is a result of several criteria. For example, CAG requested the feedback from stakeholders (airlines and ground handlers) during the evaluation of a new Common Use system, where the stakeholders were invited to "play" with hardware proposed by different vendors.</i> Self-Service: RMS: A-CDM: AMS:
Other comments?

**Figure 30. Low response as a result of complex questions.**

- c) Question 7 (IT intensity), as shown in Figure 31, was created to obtain information about the ownership of airport, passenger traffic, total airport revenue, total operating expenses, the IT spend as a percentage of revenue (i.e. IT intensity) and the major IT costs. Despite several requests and follow-up with the airport, it was not possible to obtain information IT costs.

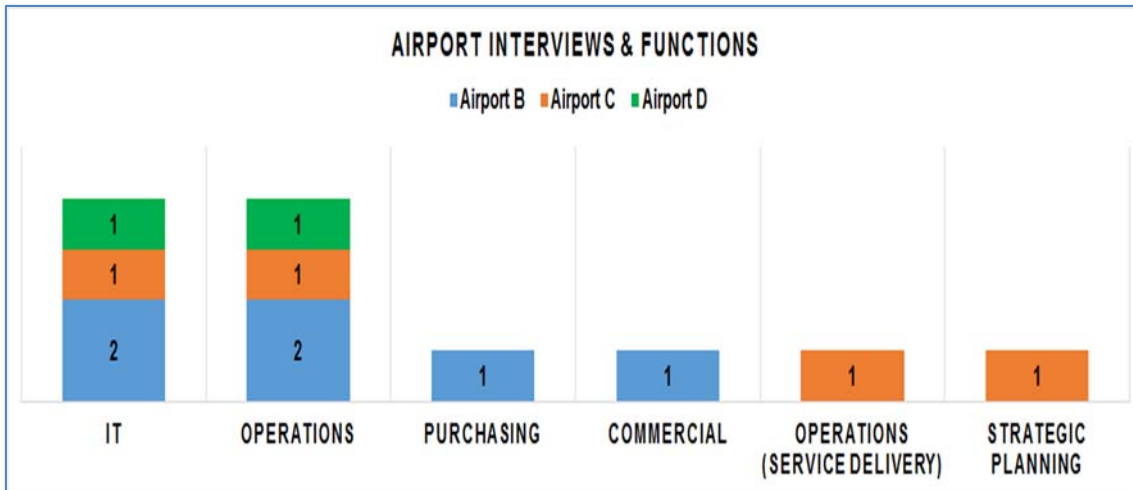
Airport Name:
Airport Ownership: Private Public Mixed Corporatised N.B.: Corporatised airport: allocation of the non-regulatory functions of the airport under a new airport company which will undertake the operational functions of managing the airport.
Number of passengers handled, and if applicable, split into domestic and international: <ul style="list-style-type: none"> <li>• 2010: (Dom: )   (Int: )</li> <li>• 2009: (Dom: )   (Int: )</li> <li>• 2008: (Dom: )   (Int: )</li> </ul>
Airport Revenue and Expenses: Total Revenue: <ul style="list-style-type: none"> <li>○ 2010: _____</li> <li>○ 2009: _____</li> <li>○ 2008: _____</li> </ul> Total Operating Expenses: <ul style="list-style-type: none"> <li>○ 2010: _____</li> <li>○ 2009: _____</li> <li>○ 2008: _____</li> </ul>
IT Spend <ul style="list-style-type: none"> <li>• Total IT spend (as % of revenue) in <ul style="list-style-type: none"> <li>○ 2010: _____ %</li> <li>○ 2009: _____ %</li> <li>○ 2008: _____ %</li> </ul> </li> <li>• Total IT spend (as % of operating expenses) in <ul style="list-style-type: none"> <li>○ 2010: _____ %</li> <li>○ 2009: _____ %</li> <li>○ 2008: _____ %</li> </ul> </li> <li>• What are the major IT costs? <ul style="list-style-type: none"> <li>○ 2010: Applications: %   Infrastructure: %   Telco: %   Personnel: %   Other: %</li> <li>○ 2009: Applications: %   Infrastructure: %   Telco: %   Personnel: %   Other: %</li> <li>○ 2008: Applications: %   Infrastructure: %   Telco: %   Personnel: %   Other: %</li> </ul> </li> <li>• Please give an approximation if the exact percentage is not available. Please consider IT spend to include staff, service contracts &amp; depreciation of assets</li> </ul>

**Figure 31 Question 7: IT intensity**

These identified issues were taken into consideration during Step 4 of the validation of the questionnaire.

### 4.5.3 Step 4 – Remaining interviews

Figure 32 shows the remaining three airports that were interviewed as follows Airport B in Northeast Asia the interview took place in July 2013; Airport C in Australia the interviews took place in April 2013, and Airport D in Europe the interviews took place in October 2013. The questionnaire was the same as the one used in the pilot interviews in order to obtain comparable feedback about the questionnaire.



**Figure 32. Remaining airports and functions.**

The main difference with the pilot was the taping of the interviews using a voice recorder application, a standard mobile phone application. Because of different audio formats, the original recordings had to be converted into mp3 format.

The interviews were face-to-face interviews and took place in three countries, with a total duration of 12 hours, and a total recording of over 10 hours. There are two reasons to explain the difference between the duration and recording, the first one was the request from some of the interviewees to discuss additional points but they did not want them recorded, and the second one was due to a technical problem with the recording device (i.e. 33 minutes). Additional information about the interviews is shown in Chapter 5.

The key findings per airport regarding the questionnaire are:

- **Airport B (Northeast Asia):** The interviews required more intervention from the interviewer to explain or to clarify the questions. It was important to reassure the respondents that the IT-related questions were about the function and not the person (i.e. CIO). This airport suggested the inclusion of Procurement and Commercial departments. However, the information obtained in the interview with the commercial department was not relevant to this research, so it was disregarded.
- **Airport C (Australia):** There were mixed approaches in terms of handling the questionnaire, whereas the majority used the printed questionnaire as

a reference and follow the interview style of “question and answer”. The exception was the last one, Airport Ops, who preferred to go through the questionnaire and record the responses on the paper.

- **Airport D (Europe):** There were only two respondents, one representing IT and one from Operations. There were no specific issues with these two respondents regarding the questionnaire.

#### **4.5.4 Step 5 – Key discoveries**

The validation of the questionnaire was an important step because it tested the questionnaire as a data collection instrument, in addition to providing an insight into an airport’s perception of IT and its role in the performance of the airport.

This subsection describes the key findings relating to the questionnaire and the impact it had on the objectives, and the update of the questionnaire in terms of its structure and questions. The analysis of the answers are described in Chapter 5.

##### **4.5.4.1 Update of the objectives**

The questionnaire was created to obtain information to answer four questions that are at the core of this research:

- 1) Does IT culture impact airport performance?
- 2) What are the airport characteristics that impact airport performance?
- 3) What is the airport’s IT intensity?
- 4) What are the IT systems that impact airport performance?

The questionnaire in its original form proved to be a good instrument to obtain information that would answer the four questions above, except regarding an airport’s IT intensity, because it required the airport to provide financial information (e.g. revenues and operating costs), but most importantly to provide information on IT spend.

Airport A was the only airport that provided the answers related to IT intensity, whilst the other airports provided information related to traffic, revenues and



costs, but did not provide the IT spend. Repeated requests were made, but there was no success in getting a response.

As result of this outcome, the decision made was to remove this question from the online questionnaire, because the probability of the respondents providing the answer would be very low and the IT spend information would reside with IT and Finance. However, other functions, especially airport operations would not know how much the airport spent on IT.

Therefore, the IT intensity was no longer considered as part of the research to establish the relationship between IT and airport performance.

#### **4.5.4.2 Update of the questionnaire**

The design of the final questionnaire is very different, because it had to be adapted to be used in the online survey. The questions are the same, but they have been redrafted and are more explicit in their meaning as the survey is self-administered and is without the intervention of an interviewer.

The questions were grouped under four headings:

- The Airport: The questions in this section are the easy questions, which to invite respondents to continue with the survey instead of putting them off and dropping out altogether.
- Airport IT culture: The aim is to understand the role of IT within the airport with three closed questions: one question to determine the respondent's opinion and two to determine their preference or ranking order.
- Airport performance: The survey defines airport performance; the change compared with the original questionnaire is the addition of the Airport Service Quality indicators to measure airport performance, which become more apparent after the interviews.
- Airport performance and Service Level Agreements: This was given more prominence in the online questionnaire, as result of the interviews that were used to measure airport performance.

The final version of the online questionnaire is found in the Appendix D of this report.

## 4.6 Population

This section describes the target population of the online survey. The target population was based on the author's existing business contacts, lists such as ACI Conferences provided by organisers of the industry events, and web searches.

Other sources with which to build a contact database are subscription-based databases:

- Albatross Airports Database<sup>23</sup>
- CAPA Centre for Aviation

A total of 1795 contacts were initially targeted, but owing to 124 non-delivered (bounced back) emails and 63 opted-out respondents, the final target number for the online survey is 1608 as shown in Figure 33.

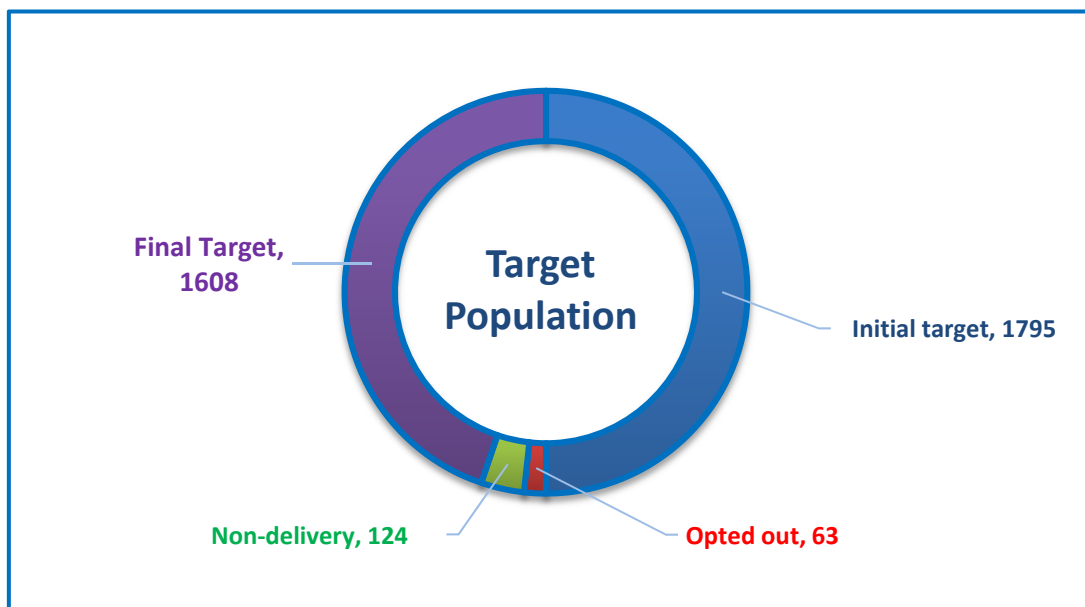


Figure 33. Target population.

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<sup>23</sup> Albatross is a subscription database with information on airports worldwide. <http://www.airport-information.com/website/index.php/en/database-access-en>

The final target population is representative of 129 countries and 445 airports, with eight countries representing almost 45% of the target population as shown in Table 5.

<b>Countries</b>	<b>129</b>
Total airports	<b>445</b>

<b>Countries</b>	<b>Number of Airports</b>
Australia	16
Canada	19
China	17
Germany	20
Russia	32
Sweden	10
UK	20
USA	65
Total airports	199

**Table 5 Target population: country distribution and number of airports.**

In addition to distribution, it was important to have different functions in the population, as shown in Figure 34. The job functions are broad umbrella categories; for example, Administration function covers potential respondents with job titles such as Administrators, Members of the Board, Strategy, and Consulting. However, more analysis regarding job titles and functions is carried out on the people who responded to the survey.

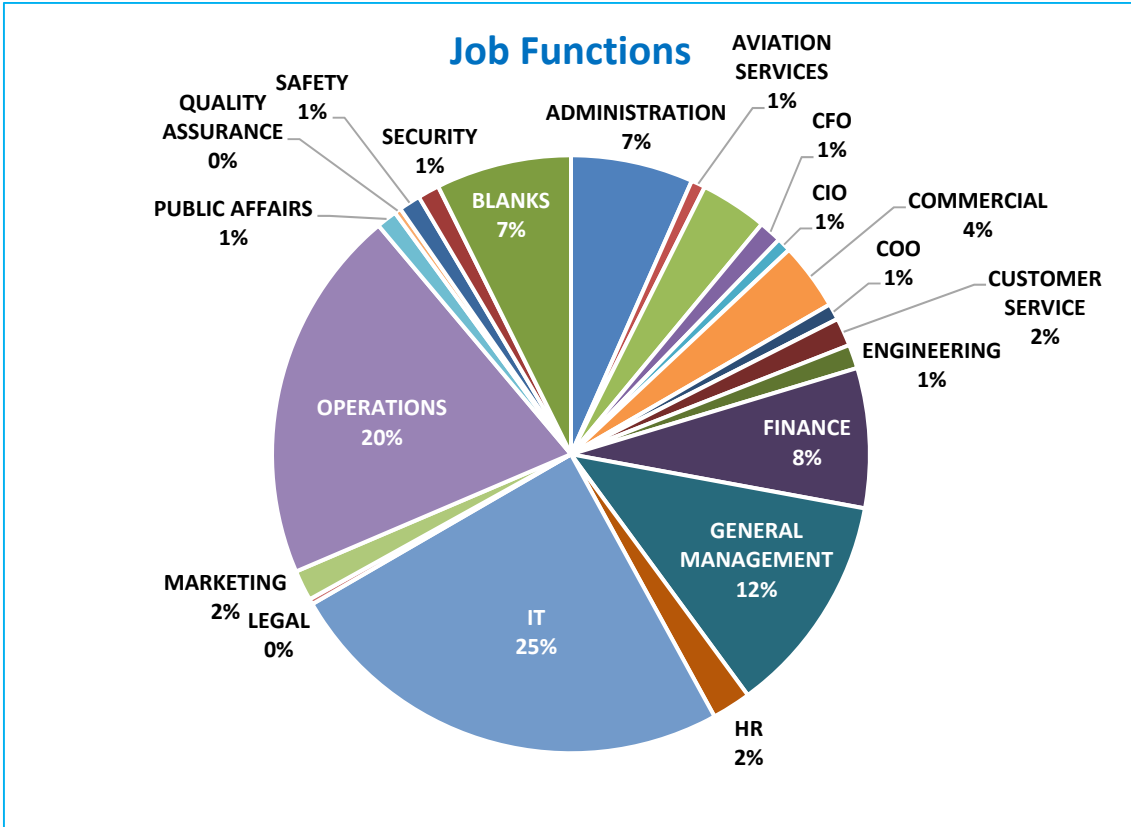


Figure 34. Job functions mix in the target population.

## 4.7 Data collection

The survey was a self-administered online questionnaire using the commercial and paid-for service of SurveyMonkey.

The paid-for subscription provided additional features that are not available with free-of-charge services. These additional services used in the data collection provided an unlimited number of questions and responses, customisation of the pages with logos and a feature “skip logic” that allowed the respondent to skip questions depending on the answer provided.

As result of the face-to-face interviews, the layout of the original questionnaire was modified in terms of structure (i.e. layout) and the content to be more concise, as described in Subsection 4.5.4.2.

The new questionnaire was created using the online tool and tested on a small group, as shown in Figure 35, which provided additional feedback regarding the

wording of some of the questions, and the need to provide a definition of terms (e.g. airport performance and ACI ASQ Indicators).



Figure 35. Online survey test.

#### 4.7.1 The survey collectors

A survey collector is a method by which to distribute the survey and can be used in different ways to suit the respondents' preferences. There are five types of collectors offered by the online company, but only two are relevant for this research:

- Email invitation: It uses the online company's email system to send out the survey by email with the ability to track responses. It offers templates, but for this research an email was drafted that retained key elements, such as opting out and the sender's personal email for further contact.
- Web link: It uses the sender's email by creating a link to the online survey (<https://www.surveymonkey.com/s/9L3WSKV>)<sup>24</sup>, and it can be used on

<sup>24</sup> This web link to the survey is for illustration purposes only, because the collector is closed.

social media networks (e.g. Facebook and LinkedIn). The drawback of this collector is that although it records the responses it does not know who responded, so making it difficult to track responses because the questionnaire does not ask for a respondent's name. This type was used as the test, but the reconciliation more complicated. For example, in order to determine the name of the respondent, the IP address was used to determine the location and match it with the respondent.

The other three types are: Website, where the survey is posted on the website; Facebook, where the online survey is posted on people's feeds; and Targeted Audience, which refers to buying survey responses from a certain demographic.

In this research, the Email Invitation collector was used with four nicknames, as shown in Table 6. These nicknames are for internal use and reference only.

PhD Thesis Survey	Survey CK additional names	Personal Invitation	PhD_ Final Push
Target: 1706 names	Target: 79 names (additional names)	Target :10 names (additional names)	Target: 1265 (from the original list)
Sent four times (including reminders): 09 Jul 2014 21 Aug 2014 02 Sep 2014 23 Sep 2014	Sent three times (including reminders): 22 Aug 2014 02 Sep 2014 23 Sep 2014	Sent twice (including reminders): 22 Aug 2014 09 Sep 2014	Sent once: 22 Oct 2014

**Table 6. Email collectors.**

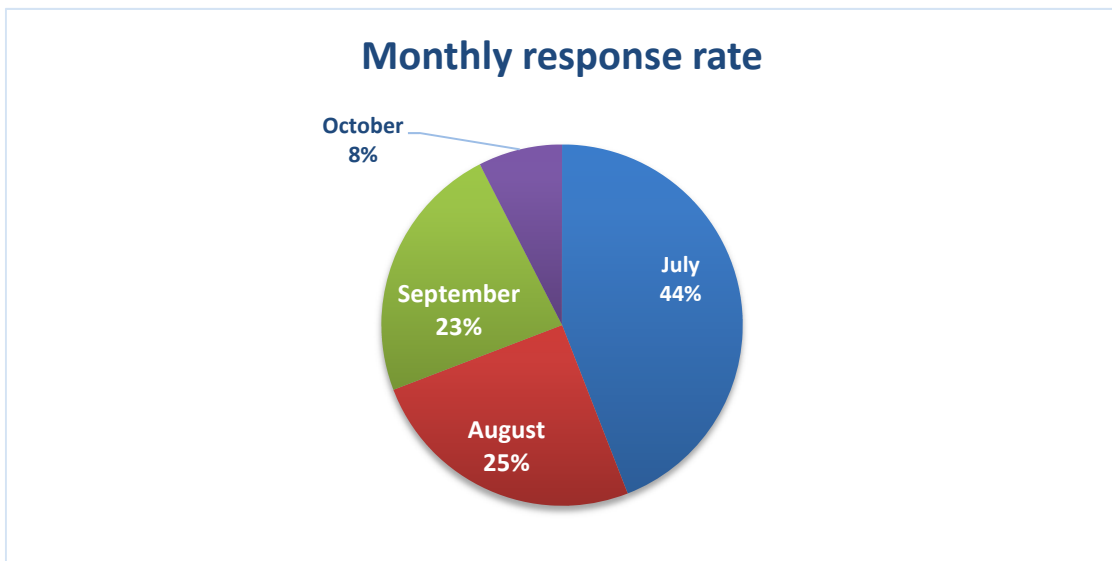
The four nicknames were used to track the inclusion of an additional 79 names plus the 10 with personal invitations. The style of the message also changed to show the recipient that it was not a simple reminder automatically generated by the system.

The content of the letters of the first collector (PhD Thesis Survey) also changed from an invitation to participate in academic research to a request for help. The first reminder indicated that a shorter response time was required (reduced from 10 minutes to 5 minutes), and the third and fourth reminder offered a copy of the aggregated results.

The second collector (CK Additional Names) was created to include additional names, and the message is the same as the one used in the first collector. The third collector (Personal Invitation) was used to target recipients who the author personally met, and the invitation addressed the recipient only by their first name (one response out of 10 invitations although six of them were interviewed). The last collector (PhD Final Push) was a final request for help. Copies of the letters are found the Appendix E of this report.

After the first collector email was sent out, a few responses come back saying that the recipient was not involved in the IT field and would participate in the survey. So in the reminder letter, a paragraph was added that IT expertise was not required to respond to the survey.

The statistics generated by the data collection tool shows that the month in which the survey was launched had the highest response rate within the four months the survey was opened as shown in Figure 36.



**Figure 36. Online survey monthly response rate.**

Owing to a glitch with the online survey system, the IT culture portion of the questionnaire with three questions was hidden. This issue was discovered after the launch of the online survey and was noticed during the check of the responses, in particular a response from an airport CIO who would otherwise not have left these three questions blank.

Once the problem was identified, the online survey was temporarily closed (i.e. no one could access the survey). At the same time, the contact list of all respondents who responded to the questionnaire up until it was temporarily closed was downloaded and a new target list created.

A separate collector was created (PhD Thesis: The Airport IT culture), containing only the three “hidden” questions in order to avoid having the recipients to go through all nine pages of the original questionnaire. This collector was sent to 74 people who had already completed to the original survey but “skipped” this section. Three collectors including two reminders were sent, which resulted in 44 responses out of the 74. The survey was re-opened and all collectors (i.e. the data collection) closed on 03 November 2014.

The use of the online survey tool has its advantages in terms of creating, sending and tracking responses. The tool also provide basic descriptive analysis of the results (e.g. frequencies and averages).

#### **4.7.2 Data cleaning**

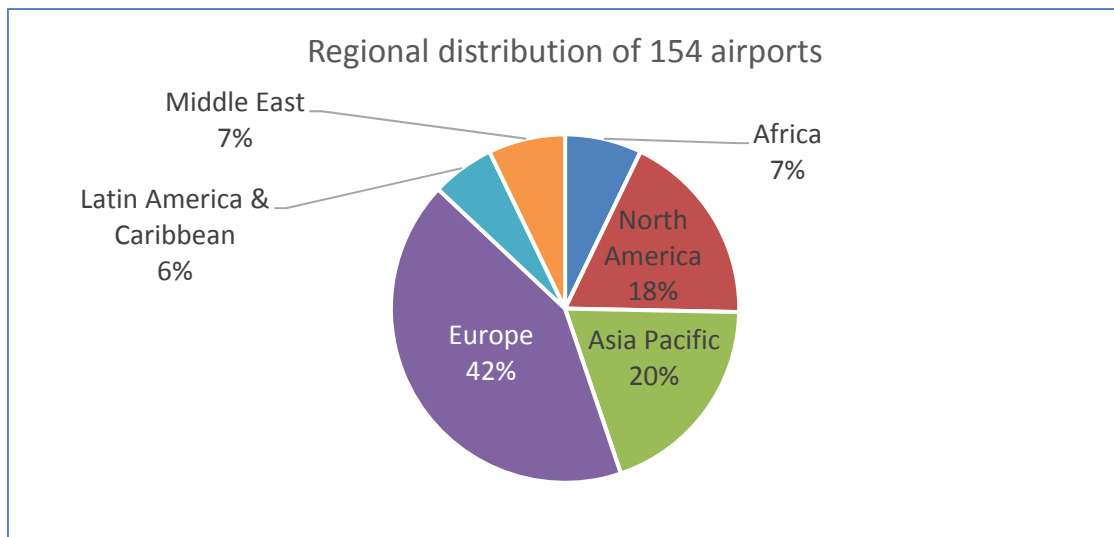
The data collector was closed, with a total of 275 responses covering 75 countries and 158 airports. The results of the survey was exported into a spreadsheet, which was then used to manipulate the data.

The data collector was designed to ensure the questionnaire was easy to complete, so it focused on key questions being addressed by the research, whilst additional information such as region, country, ownership, passenger traffic, cargo, movement, and revenue information was collected separately.

The initial analysis of the responses resulted in removing 15 responses: blank or incomplete responses from three airports located in South Korea, Sudan and Czech Republic; three ground handling companies in Spain, Jordan and Ukraine; one subsidiary company of a French Airport; one infrastructure company in France; one government agency in Cambodia; and one airport in South Africa whose statistics could not be found.



The data cleaning resulted in the deletion of four countries (i.e. France, Spain, Sudan, and Ukraine) and four airports in Czech Republic, South Korea, South Africa, and Sudan. As Figure 37 shows, the final regional distribution of 154 airports that took part in this research with the 80% of the airports are represented by three regions: Europe, Asia Pacific and North America.



**Figure 37. Regional distribution of airports.**

Additional information was collected and input manually for each airport (e.g. ownership, passenger, movement, and revenue) and different sources were used to collect the information:

- Albatross System by Momberger, a specialist database with traffic (passenger, cargo and movement) and terminal information
- CAPA Centre for Aviation – Airport Database
- FlightGlobal – 100 airport groups’ financial information
- ACI Airport Economics Report 2013
- Airport websites

The reason for using multiple databases was as a result of a lack of a single repository containing all the airport-related information.

The data was normalised and special attention given to the reported units for number of passengers, aircraft movement and currency, with all converted to US

dollars and using Purchasing Power Parity (PPP)<sup>25</sup> conversion factor from the World Bank.

Financial information tends to be the most difficult data to be obtained, because out of 154 airports the financial data (i.e. revenue) was available for 92 airports (60%). For the remaining 62 (40%) airports, a solution using ACI Economics data to derive the missing revenue was used and is described below.

The ACI Economics Report analysed 680 airports, presents data and economic indicators of airports for the financial year 2012. The data provided is aggregated based on airport size, ranging from less than 1 million passengers to more than 40 million passengers; regional location (i.e. Asia Pacific, Europe, Middle East, Africa, America, and Latin America and the Caribbean); and ownership structure (i.e. public, private and mixed).

The report produced several indicators, and the Airport Financial Performance per Passenger (US\$) was used to estimate the airport revenue for those whose information was not available in the public domain. Table 7 below shows the information provided in the ACI Economics Report.

	Per Passenger (US\$)	Total Income
Size Category	<1m	15.98
	1-5m	16.12
	5-15m	18.26
	15-25m	22.12
	25-40m	22.27
	>40m	19.44
Region	Africa	17.08
	Asia Pacific	19.59
	Europe	27.57
	Latin America-Caribbean	14.37
	Middle East	24.14
	North America	16.14
	World	20.28

**Table 7. Airport Income in US\$ per passenger in 2012**

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<sup>25</sup> PPP is an exchange factor that converts the currency of a country required to buy the same amount of goods/services that US dollars would buy in the United States.

The sample of 25 airports (i.e. six for North America, Europe and Asia Pacific; five for Latin American and Caribbean; one for Africa; and one for Middle East) were used to compare the degree of change between the reported versus the estimated revenue, using either the averages per size or averages per region.

The ACI Economics Report indicated that due to the presence of outliers, the distribution was skewed and pushing up the income per passenger. An alternative of medians and quartiles was also provided in the report. These were compared separately, generated larger degrees of changes and were disregarded, as shown in Table 8.

	MEL	SYD	DPS	SIN	TPE	BKK
1 Q	-81%	-86%	-85%	-49%	-76%	-78%
Median	-73%	-81%	-79%	5%	-66%	-70%
3 Q	-36%	-55%	-50%	83%	-20%	-28%

**Table 8. Degrees of changes for estimated revenues based on revenue distribution.**

The regional mean income per passenger was chosen to derive total income or revenue for the remaining airports, because it provided for most of the regions a smaller degree of change (in absolute terms) compared with average income per size. The table with the comparisons can be found in Appendix F.

The data set is clean and complete with revenue information for all 154 airports, and with the information on movements, the airport performance variable was created: Airport Revenue per Movement.

One other element that required normalisation was ownership of airports, because the confusion arises regarding the ownership versus management. For example, in the United States, the Federal or Municipal government may own some airports, but private companies manage the terminal (e.g. JFKIAT is the operator of New York's JFK Terminal 4, which is also the only non-airline operated terminal at JFK).

Gillen (2011) described the evolution of the airport ownership models as a result of airports moving from public utility to adopting business models. As a result, seven categories were described:

- Government owned and operated

- Government owned and privately operated
- Public Private Partnership (i.e. lease or concessions)
- Independent not-for-profit corporations (e.g. majority of Canadian airports)
- Fully private (e.g. via an initial public offering or via trade sale)
- Partially private with public controlling
- Partially private with private controlling

Oum et al. (2008) describe similar categories; however, they introduce 100%-owned government corporations as an additional category (e.g. Hong Kong and Singapore have created government-owned corporations to manage, respectively, Hong Kong International Airport and Singapore Changi Airport). Oum also uses the terminology “mixed”, which is the equivalent to Gillen’s partially private airports.

For this research, airports have been classified using similar categories:

- Corporatised: public corporation (e.g. Singapore and Hong Kong)
- Public: government owned (e.g. Atlanta)
- Private: 100% private investors (e.g. London Heathrow and Sydney)
- Mixed: 50% public and 50% private (e.g. Stuttgart)
- Mixed (public majority): public (i.e. government) has a majority share (e.g. Zurich: Canton of Zurich has 47% and City of Zurich)
- Mixed (private majority): private enterprises have a majority share (e.g. Auckland with two city councils together own 22.77% of the airport)
- Public (lease/concession): the government leases the management of the airport (e.g. San Juan Airport, a Public Private Partnership between the government and private sector to manage and operate the airport)

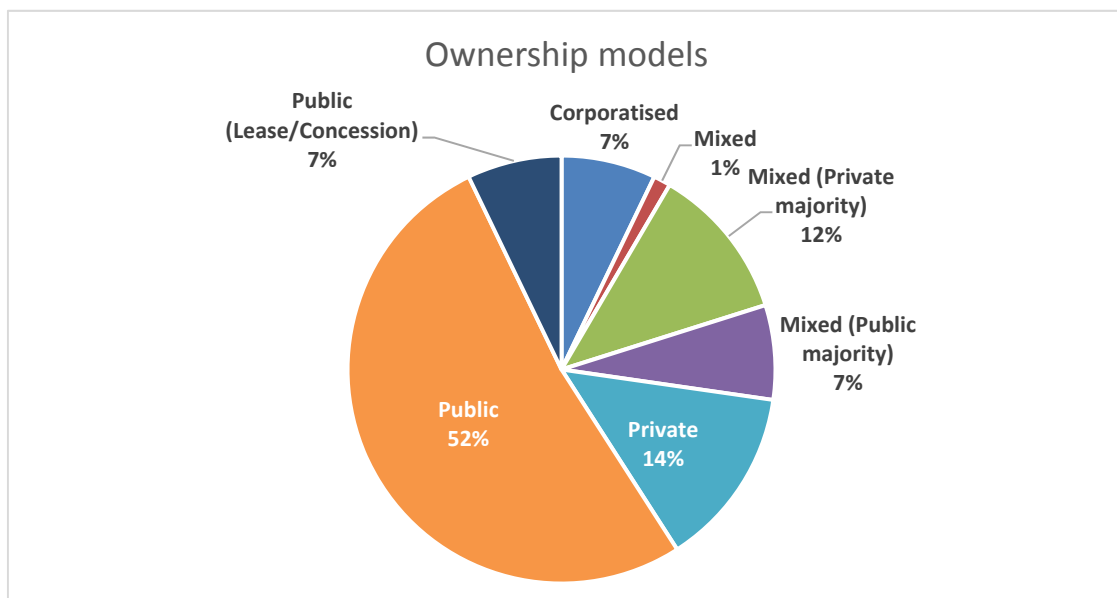
It can be argued that some airports may be either classified as a mixed ownership or a public (lease/concession). For example, two cases of the recently privatised airports in Brazil (GRU Sao Paulo International Airport and GIG Rio de Janeiro International Airport), because in both cases the Infraero<sup>26</sup> still retains 49%

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<sup>26</sup> Infraero is a government corporation set up to operate the main commercial airports in Brazil.

control of these airports, which can be classified in both categories as a concession and as mixed ownership. However, they are both classified under the Public (Lease/Concession), because under the agreement the concessionaires are required to develop the airport infrastructure (i.e. build a new terminal or renovate the existing terminal). The table with the list of the airport ownership models can be found in Appendix G.

Figure 38 shows that 66% of airports are owned by governments either through public ownership (52%), government-owned corporations (corporatised airports 7%) or through a mixed ownership with a public majority stake (7%).



**Figure 38. Percentage distribution of airport ownership models.**

It is not an objective of this research to determine the relationship between airport performance and ownership models (Oum et al., 2006, 2008; Vogel, 2006, Graham and Vogel, 2013; Vasigh et al., 2014), but instead to establish a relationship between ownership and IT culture that could impact the relationship between airport performance and IT.

The normalised data was imported onto SPSS (Statistical Package for Social Science) for the statistical analysis and the results are discussed in more detail in the next chapter.

## **4.8 Statistical Methods**

This subsection describes the statistical methods used in the study.

### **4.8.1 Independent samples t-test**

To test the differences between the airports that use ASQ and those that don't in terms of passenger satisfaction and airport environment, two independent samples t-test was applied to validate the following hypothesis:

***H4b: there is a difference in airport performance based on the use of ASQ***

The independent sample t-test is appropriate, as there are only two levels for the factor being tested (use of ASQ). It is used to determine if the means of the two groups (Q10\_ASQ\_dimen (12)) of airports differ (i.e. airports that use ASQ and airports that do not use ASQ).

### **4.8.2 MANOVA**

The multivariate analysis of variance (MANOVA) statistical model is used to test if the vectors of means of the IT culture factors based on ownership structure are equal. MANOVA was applied to test the following hypothesis:

***H2b2: There are differences in IT culture based on different ownership structures***

The model includes only one factor (ownership) with multiple levels (corporatized, public, private, mixed, mixed - public majority, mixed - private majority, public – lease-concession) and three dependent variables: the IT culture factors (role, benefit, importance). The groups based on ownership structure are independent. The results of this test indicate if there are differences in the IT culture factors based on ownership.

### **4.8.3 Principal components analysis**

Principal Component Analysis (PCA) is a statistical method used to find patterns in the data and use them to reduce the number of dimensions in the data without losing the information contained in the data. The three IT factors of interest (role,

importance and benefits), as determined from the literature review, were established using the questionnaire. The answers to the four questions addressing the IT role were condensed into the IT role factor variable, the answers to the five questions addressing the IT importance were condensed into the IT importance factor variable and the five questions addressing the IT benefits were condensed into the IT benefits factor variable. The reduction in the number of variables that define IT culture from 14 to 3 allows for possible relationships to be revealed, where previously such relationships would be undetected. The answer to the questions grouped under one factor could possibly correlate, as they measure different aspects of the same concepts. Such correlations would lead to erroneous conclusions in subsequent statistical analyses of the data (regression and ANOVA). Lastly, including too many predictor variables (in this case all 14 variables) could lead to collinearity, where the models lack degrees of freedom and are over-fit and the results are inaccurate. A reduction in the dimensions of the data preserves the information, while avoiding the above mentioned problems.

When variables are grouped under one factor, it is customary to check for the reliability of the construct. It is a measure of how closely related are the answers to the questions that are grouped under one factor, thus providing a measure for internal consistency. A high value for the reliability coefficient indicates that the answers to the questions grouped under one factor measure the same latent aspect of IT culture.

Principal Component Analysis (PCA) was applied to determine the factor scores for IT Culture, which were used to test the following hypotheses:

***H1: There is a relationship between IT culture and airport performance***

***H2a: There is a relationship between management preferences to use Service Level Agreements (SLA) and IT culture***

***H2b1: There is a relationship between ownership structure and IT culture***

***H2b2: There are differences in IT culture based on variation in ownership structures***

***H2c: There is a relationship between outsourcing and IT culture***

**H2d: There is a relationship between competition Intensity and IT culture**

#### 4.8.4 Correlation

Correlation analysis is used to test the following hypotheses:

**H2a: There is a relationship between management preferences to use Service Level Agreements (SLA) and IT culture**

**H2c: There is a relationship between outsourcing and IT culture**

**H2d: There is a relationship between competition Intensity and IT culture**

To test the above hypotheses, *Management* as an index score of SLA obtained from answers to Q15 of the survey (Q15\_index) is used to measure *management preference*; *outsourcing* is measured as an index score obtained from answers to Q3\_index of the survey; and *competition intensity* is measured by Q2\_Competition in Questionnaire.

The correlation test determines whether there is a linear relationship between two variables, where one of the variables is an IT culture factor and the other variable is an airport characteristic. The results of the test indicate if there is a linear relationship that can be extrapolated to the population of study, not just the sample available. The overall Pearson's  $r$  correlation coefficient is presented below, where  $X$  and  $Y$  are the two variables being tested (an IT factor and an airport characteristic) and  $N$  is the number of observations.

$$r = \frac{N\sum XY - \sum(X)\sum(Y)}{\sqrt{(N\sum X^2 - (\sum X)^2)(N\sum Y^2 - (\sum Y)^2)}}$$

While the Pearson's  $r$  correlation coefficient can be used for normally distributed data (SLA and outsourcing), the test cannot be used for the association between competition and IT culture factors. This is a result of the variable completion being ordinal and categorical. The non-parametric Spearman's rho test is used instead, where the general formula is:

$$r_s = 1 - \frac{6\sum d^2}{N(N^2 - 1)}$$



The difference between ranked values for each pair is denoted as  $d$ , while  $N$  is the total number of observations.

Correlation analysis is also applied to test ***H6 (There is a relationship between the selected IT systems and airport performance)*** to determine if there is a linear relationship between airport performance (REV\_MVT) and each of the selected systems (Q12\_MVT, Q12\_cute, Q12\_rms, Q12\_aodb, Q12\_fids, Q12\_bag, and Q12\_acdm). A multiple regression model was not applied to the data, as the number of independent variables (selected systems) and the small sample size could render the model over-fit and the results unreliable.

Correlation analysis is also applied to test ***H4a (There is a relationship between ASQ dimensions and airport performance)*** to determine the relationship between the eight major ASQ dimensions (passenger satisfaction, check-in, security, way-finding, facilities, access, arrival, environment) and airport performance. Multiple regression model was not applied to the data, as the number of independent variables (ASQ dimensions) and the small sample size could render the model over-fit and the results unreliable.

#### **4.8.5 Multiple Regression Analysis**

The following hypotheses may be tested using multiple regression:

***H1 There is a relationship between IT culture factors (i.e. role, benefit and importance) and airport performance***

In the regression model the dependent variable is airport performance and the independent variables are the IT culture factors, with ownership and passenger satisfaction as control variables. The regression model can determine if the IT culture factors are predictors of the airport performance. It has a probabilistic error term, which accounts for the variability in airport performance values that cannot be explained by the IT culture factors, ownership or passenger satisfaction. The overall regression equation is presented below:

$$REV_{MVT} = \beta_0 + \beta_1 FAC1_{Q_5} + \beta_2 FAC1_{Q_6} + \beta_3 FAC1_{Q_7} + \beta_4 PAX + \beta_5 Ownership + \varepsilon$$

***H2b1: There is a relationship between ownership structure and IT culture***

The relationship between ownership and the three IT culture factors cannot be analyzed using a correlation model because ownership is a nominal variable and as such there is no inherent order to the coding of the data. Correlation models can only be applied to variables that have values that can be ordered and where the order has a meaning. Therefore, to determine the relationship between ownership structure and the three IT culture factors, three regression models were applied. The dependent variable was one of the IT culture factors and the independent variables were dummy variables created to represent one type of ownership structure each, with public ownership as the reference category. The dummy variables were created as an increase in one unit in the coding of ownership has no meaning (there is no inherent order in the coding). As such, a model with one independent variable representing ownership would render results that are meaningless. The regression model can determine if the ownership dummy variables are predictors of IT culture factors. The regression model has a probabilistic error term, which accounts for the variability in IT culture factors values that cannot be explained by the ownership dummy variables. The general regression model with an IT culture factor as the dependent variable is presented below:

*ITCulture Factor*

$$= \beta_0 + \beta_1 DCorporatised + \beta_2 Private + \beta_3 Mixed \\ + \beta_4 Mixed_{Public} + \beta_5 Mixed_{Private} + \beta_6 Public_{Lease} + \varepsilon$$

To examine the relationship between airport performance and airport characteristics, that is to test ***H3 (There is a relationship between airport characteristics and airport performance)***, a multiple regression is specified as follows:

$$REV_{MVT} = \beta_0 + \beta_1 Q2Competition + \beta_2 Q3Index + \beta_3 Q15Index + \beta_4 PAX + \varepsilon$$

In the regression model the dependent variable is airport performance (REV\_MVT) and the independent variables are the airport characteristics

(*Q2Competition*, *Q3Index*, *Q15Index*), with passenger satisfaction (*PAX*) as the control variable.

To test **H5 (*IT investment is associated with airport performance*)**, multiple regression is used to determine whether airport performance is affected by the independent variables where is an index score used to measure investment (*Q13\_14\_index*) after controlling for airport ownership and airport size. The model is specified as follows:

$$REV_{MVT} = \beta_0 + \beta_1 Q1314Index + \beta_2 Ownership + \beta_3 PAX + \varepsilon$$

#### 4.8.6 Summary

This subsection provides a summary of the key variables used in this study, which are shown in Table 9. The full list of the variables is available in Appendix H.

Label	Variable	Measure
Size	PAX	Scale
Airport performance	REV_MVT	Scale
Ownership	Ownership	Nominal
There is intense competition from other airports	Q2_competition	Scale
SLA_index	SLA_index	Scale
Outsourcing_index	Outsourcing_index	Scale
REGR factor score of Q_5	FAC1_Q_5	Scale
REGR factor score of Q_6	FAC1_Q_6	Scale
REGR factor score of Q_7	FAC1_Q_7	Scale
Q_3_index	Q_3_index	Scale
Q_15_index	Q_15_index	Scale
Q_13_14_index	Q_13_14_index	Scale

**Table 9. Summary of variables**

The Table 10 (below) contains all the statistical techniques used to test the hypotheses.

Hypothesis	Method	Variables
H1	Principal components analysis (Factor analysis) – IT culture	RQ5_strategic, RQ5_operational, RQ5_custodian, RQ5_transform, Q6_critical, Q6_growth, Q6_enhance, Q6_automation, Q6_performance, RQ7_different, RQ7_costs, RQ7_products, RQ7_innovation, RQ7_BI
	Multiple regression	Dependent variables: REV_MVT Independent variables: FAC1_Q_5, FAC1_Q_6, FAC1_Q_7 Control variables: Ownership, PAX
H2a	Correlation	FAC1_Q_5, FAC1_Q_6, FAC1_Q_7 Q7_SLA_index
H2b1	Multiple regression	FAC1_Q_5, FAC1_Q_6, FAC1_Q_7 Ownership
H2b2	MANOVA	FAC1_Q_5, FAC1_Q_6, FAC1_Q_7 Ownership
H2c	Correlation	FAC1_Q_5, FAC1_Q_6, FAC1_Q_7 Outsourcing_Index
H2d	Spearman's Rank Order Correlation	FAC1_Q_5, FAC1_Q_6, FAC1_Q_7 Q2_Competition
H3	Multiple regression	Dependent variable: REV_MVT Independent Variables: Q2_Competition, Q3_Index, Q15_Index Control variables: PAX
H4a	Correlation	REV_MVT Q11_pax, Check-in: Q11_ckin, Security: Q11_security, Q11_wayfinding, Q11_facilities, Q11_access, Q11_arrival, and Q11_environ
H4b	Two-sample t-test	Q10_ASQ_dimen, Q11_pax, Q11_environ
H5	Multiple regression	Dependent variables: REV_MVT Independent variables: Q13_14_index Control variables: Ownership, PAX
H6	Correlation	REV_MVT Q12_MVT, Q12_cute, Q12_rms, Q12_aodb, Q12_fids, Q12_bag, and Q12_acdm

**Table 10. Summary of the statistical techniques used to test each hypothesis**

## **5 FINDINGS: CASE STUDIES AND SURVEY**

Chapter 5 presents the findings of the case studies and the online survey. The analyses are discussed in two sections, and elements of the analyses refer to both Chapter 3 (research questions and hypotheses) and Chapter 4 (methodology).

### **5.1 Case Studies**

#### **5.1.1 Introduction**

This subsection presents the findings of the case studies, which provide insight into the deployment of technology and the impact on airport performance. The case studies are the result of face-to-face interviews with executives of four airports in Southeast Asia, Northeast Asia, Australia, and Europe. The interviews were also used to validate the questionnaire that was later used in the online survey.

Airport industry IT investment is set to increase to US\$7.8 billion, which over a period of three years represents a compound annual growth of 16.4% (SITA, 2015), and these investments are being made to address the industry's top three challenges: increase passenger processing, improving airport operations (e.g. better management of resources), and improving baggage processing. By addressing these three challenges, the airport industry is effectively addressing ways to improve their operational performance. In other industries, in addition to enhancing performance, investments are also being made to reduce costs (Hung et al., 2013). The relationship between IT investment and business performance has been a widely researched subject, Some studies show a positive and significant relationship between investments in IT and performance while others do not (Sheng and Mykytyn Jr, 2002).

Despite the increase in investment by airports, and reliance on airport systems such as integrated financial systems (e.g. Enterprise Resource Planning – ERP), operational systems (e.g. Flight Information Display System), passenger processing systems, and others systems there have been few studies that have

sought to address the relationship between IT and airport performance. The deployment of airport systems can impact airport performance. Suppliers of such systems will claim that their solutions will bring tangible benefits in terms of reducing passenger processing time, reducing queuing time, cost savings in better utilisation of resources, and reducing the number of mishandled baggage. However, there are other factors beyond investment in IT that would be relevant in the assessment of the relationship between IT and airport performance.

These other factors are:

***IT culture:*** This is an important factor because IT culture can influence not only the adoption of technology and the deployment of IT by an airport but ultimately the success of an IT programme. The components of IT culture addressed in this research are: the role of IT, the importance and the benefits of IT. Each of the components have been broken down into several sub-groups as shown below.

### **Role of IT**

- Strategic: an active role in defining the airport's strategic goals
- Operational: to improve the airports' efficiency
- Custodian: responsible for all IT-related matters of the airport
- Transformational: an active role in transforming the airport through the deployment of technology

### **Importance of IT**

- Mission critical
- Key to the airport's growth
- Create new products or services
- Address the airport's IT training needs
- Fulfil the airport's IT needs
- The contribution of IT to airport performance

### **Benefits of IT**

- Enable the airport to do things differently and become more competitive
- Help the airport reduce costs

- Improve decision making through business intelligence
- Enable the airport to differentiate itself through the introduction of new products or services
- Bring and encourage innovation

***IT investments and systems:*** airports are investing in technology (i.e. systems) to improve operational processes. The aim is to identify which of the following processes: passenger and baggage, runway, airport operations, airport security, business intelligence, environmental initiatives, other support functions are important for airports, and the reasons for investing on specific systems (e.g. Self-Service, Airport Resource Management, Airport Collaborative Decision Making, Airport Management Systems, and other systems).

***The airport and its marketplace:*** the three elements included in this component are: management preferences to use service level agreements to monitor and measure performance, the importance of skilled resources and their availability. The marketplace refers to the intensity of competition and whether it drives airports to introduce new products/services or whether IT gives them a competitive advantage.

***Performance measures:*** the aim is to determine how airports measure performance, and their views on the relationship between IT and airport performance.

Therefore, the case studies aim to explore those factors and to determine the extent to which airports consider them relevant in the assessment of IT on airport performance.

Anonymity has been requested by all participants. Therefore, their names and the identity of the airports have been anonymised. The case studies refer to Airport A, Airport B, Airport C, and Airport D which are located in Southeast Asia, Northeast Asia, Australia, and Europe.

### 5.1.2 Case Study 1 – Airport A – hub airport in Southeast Asia

Airport A, located in Southeast Asia, has a total accumulated capacity of 60 million passengers that can be accommodated in terminal space of 1 million square metres. Over 100 airlines operate from Airport A connecting 220 cities in 60 countries and territories worldwide. The airport has a strong focus on continuously improving and developing as a hub.

The four completed interviews were with senior managers in IT and Operations, namely the Chief Information Officer (CIO), the Assistant Vice President of IT (IT AVP), the Vice President – Terminal Operations, and Vice President – Airside Operations. The table below shows the total duration of the interviews. However, the interviews were not digitally recorded.

Airport	Interviewee	Recorded Interview (Hour)	Remarks
Airport A	CIO	1:00:00	Interview not digitally recorded
	Assistant Vice President of IT (IT AVP)	1:00:00	
	Vice President - Terminal Operations	1:00:00	
	Vice President - Airside Operations	1:00:00	
Total duration of the interviews		4:00:00	

#### IT culture – the role of IT

The four different roles (i.e. strategic, operational, custodian, and transformational) were discussed with the interviewees at Airport A. All interviewees considered IT to have a high priority strategic role at the airport for two reasons: (1) IT is embedded into everything that the airport does; and (2) through IT, the airport can deliver its strategic objectives by making the airport safer, and more efficient through better resource utilisation and automation of processes.

The operational role of IT was considered a very high priority for all interviewees because IT improves the operational efficiency of the airport with regards to front-end activities that engage with passengers, airline customers, ground handlers and other stakeholders. For example, self-service check-in reduces the number



of required counters and check-in agents making the process more efficient, enabling an automatic and on-demand allocation of counters or other fixed resources such as gates or parking stands. Automation leads to improvements in the operational efficiency of the airport by eliminating the need for manual forms (i.e. automatic generation of reports), avoiding data entry mistakes and duplication (i.e. single data entry point for multiple users), and pushing information to stakeholders including passengers (e.g. flight delay information) that are all enabled by IT. However, it requires close collaboration within the airport community for them to benefit from improvements in operational efficiency.

With regards to the custodian aspect of IT (i.e. responsibility for all technology matters of the airport, including IT security and governance), the interviewees representing IT functions consider this to be a very high priority in contrast to operations, who viewed it as a medium priority. This difference of opinions can be explained with reference to organisational structure where some systems are managed by different departments and procured as business IT solutions (e.g. maintenance system). Therefore, not all systems at the airport are run by or under responsibility of the IT Department. For example, the baggage system and the building management system (BMS) are managed by the Engineering Department but not IT. However, the IT Department works with all their business partners (e.g. Engineering, Administration, and Finance) on an advisory capacity in terms of providing the appropriate governance framework to procure, deploy and operate the system. The business partners define the technology requirements and solution, and with IT they jointly define service level agreements for the new system or solution. From the perspective of the interviewees from Operations, IT is considered pervasive throughout the organisation and having a custodian in the current structure of the airport would not work; this explains why they consider this have a lower level of priority.

The transformational role of IT, as a concept to transform the airport through the deployment of technology is accepted and understood by all interviewees because IT is embedded in all aspects of airport operations, and the implementation of technology improves the efficiency of the airport both at front-

end (i.e. customer facing activities) as well as back-office (i.e. administrative and operational) activities. The airport has also seen the evolution and elevation of the role of IT from support function to a more active transformational role through earlier engagement with stakeholders, pushing the transformational benefits of IT. One example was the implementation of an automated feedback system that triggers the deployment of staff to respond immediately to negative customer feedback; this enables the airport to monitor more proactively its services, thereby improving the prospects of achieving higher passenger satisfaction scores. The interviewees also highlighted that in some cases, there is a time lag between adoption of a solution and the generated benefits. An example was the implementation of self-service check-in at the airport. The adoption rate by passengers had been quite modest, which meant the transformational benefits were also slow to materialise (e.g. reduction on passenger queues at check-in). Therefore, the transformational benefits must also consider the adoption of the solution, to truly elevate the transformational role of IT.

### **IT culture – the importance of IT**

The importance of IT has been classified into seven different categories: (a) mission critical to support business continuity; (b) key to growth of the airport; (c) to create new products or services at the airport; (d) to address the airport's needs in how to use technology; (e) to address the airport's technology needs; and (f) the contribution IT has on airport performance.

The responses from the interviewees show IT as having a very high mission critical importance to Airport A because without technology the airport would not be able to operate. There are several critical systems that can cause major disruption if they are not operational. Examples of these critical systems are Air Traffic Control, Passenger Handling, Baggage Handling, as well as the Building Management Systems that control electricity, water and air-con supplies. IT also ensures that mission critical information or data from stakeholders (i.e. airlines, ground handlers, government agencies, and airport) is distributed in a timely manner.

All interviewees also agreed that IT has very high importance when it comes to having a positive contribution to the performance of the airport because it ensures the availability of systems with no disruptions to business and services. It also helps airports to be more efficient operationally (e.g. handling more passengers and through better allocation of resources). However, they have not considered IT being an important element to grow the airport business because growth is driven by demand. The importance of IT to address the airport's training and organisational needs is not considered high because training requirements are driven by the implemented solution (e.g. a tablet-based solution for airport staff), and from an organisational perspective, IT has an enabling role by ensuring a solution meets the business requirements. The product and service enhancement role has been rated with a high importance because Airport A deploys technology to either enhance a service or an airport product. For example, the implementation of the tablet-based solution for the airport ground staff to assist passengers at the airport by providing flight information, special activities or events at the airport, terminal maps and other information that a passenger may require (e.g. location of a shop).

### **IT culture – the benefits of IT**

The benefits of IT were classified as follows: (a) to enable the airport to do things differently and become more competitive; (b) to reduce costs; (c) to improve decision making through business intelligence; (d) to enable product and service differentiation; and (e) to bring and encourage innovation. All interviewees considered cost reductions as the most important benefit expected from IT, and this is expected in the form of automation of manual tasks that in turn reduces manpower requirements. Cost reductions could also be achieved through better procurement processes, so that the IT department can challenge vendors on the economic benefits of the solution being procured.

Airport A considered that to remain competitive, and to set them apart, they have ranked with high importance the benefit of being able to do things differently, to use IT to differentiate their airport and facilitate innovation. As for Business Intelligence (i.e. to improve decision making), it was considered to be in its infancy

and growing in acceptance and adoption, and it is expected that it will bring great benefits to the airport as it will enable data mining to secure meaningful trends out of the data.

### **IT Investments and systems**

Airport A indicated that the two most important areas of investment are related to Passenger and Baggage processing, and Security. These areas are considered very important because of the impact on the quality of service provided at the airport. With a focus on a seamless passenger journey strategy where the processing of passengers (and their baggage) is intrinsically linked to security, which requires collaboration from key stakeholders to avoid potential bottlenecks (e.g. check-in, immigration, security checks) to deliver on this seamless strategy. Thus, the investments are expected to facilitate and expedite passenger and baggage processing.

Airport A was undergoing the implementation of new passenger handling systems that include passenger flow monitoring solutions and a strong focus on self-service solutions, which is aligned with the industry's investments priorities that will see 92% of airports offering self-service kiosks by 2017 (SITA Airport IT Trends, 2014). The airport is also investing in biometric screening to speed up the security process.

The interviewees were not able to provide specific information on specific systems (i.e. Self-Service, Resource Management, Airport Collaborative Decision Making, and Airport Management) and their impact on airport performance. However, the airport does have a comprehensive deployment of shared self-service kiosks for check-in as well as automated baggage drop, key automated systems for operations and resource management, and Airport Collaboration Decision Making (A-CDM).

Airport A's procurement process for IT is decentralised where individual business units manage their own procurement which is aligned with company-level guidelines and policies (e.g. tender requirements). Operations will procure solutions based on their specific needs on a project-by-project basis (e.g. new

Baggage Handling System for one of the terminals). However, IT will play an advisory role in the process by assisting in the scoping of the project, its implementation and support. During the preparation of the tender, the owner of the budget will scope the business to be addressed by the solution. The scope is shared with IT who will identify the solution required, and pre-qualify potential vendors. It is a process that normally involves multiple parties such as IT, Operations, Finance, and Procurement. A consultation may also be carried with other stakeholders such as airlines, security agencies and ground handlers because any new solution that is procured may have an impact on their activities (e.g. a common use check-in solution).

### **Airport characteristics and its marketplace**

The interviewees of Airport A were asked to indicate the airport's preference regarding the use of Service Level Agreements (SLA) to measure airport performance, the use of outsourcing to address the issues of shortage of skilled resources, and lastly their opinion about the competitiveness of the airport environment.

Airport A considers Service Level Agreements as an important element with which to measure airport performance. The response from IT interviewees to questions about the use of SLA related to Passenger Processing Time shows that they strongly agree with the statement since they procure solutions with specific SLAs in the contract. However, interviewees from Operations agree with the statement, but their real challenge is that the SLA must be agreed by key stakeholders (i.e. airlines and ground handlers) who are responsible for the process. Therefore, the SLA must be achievable by all involved stakeholders in the process in which the SLA has been applied to. One area where both IT and Operations neither agreed nor disagreed was SLA related to aircraft processing time because this is considered as a very specific airline process. However, airlines will have SLAs for services contracted to ground handlers such as ramp (i.e. loading and unloading of baggage and cargo containers), catering, fuelling, and maintenance.

Regarding the availability of resources, the interviewees agree that outsourcing is an option for Airport A to deal with resource issues, but they have also expanded on their answer to reiterate that outsourcing is a viable option for low-level tasks. Airports still face challenges with skilled resources, which is more critical from an operations perspective. For Airport A, the biggest challenge is to recruit skilled resources, and working with the Government to ensure that skilled resources are available in the marketplace through appropriate training, and a focused recruitment programme for management trainees.

All interviewees agree that the airport faces intense competition, and that IT can be used to secure a competitive advantage. Airport A also needs to continuously enhance its competitive advantage by bringing new products and services as it faces competition from neighbouring airports, and with globalisation the airport also faces competition from other regions.

### **Performance measures**

Airport A was asked two questions with a relating to the use of performance measures. The questions were: (a) IT performance and performance indicators, and (b) airport performance and relationship with IT. For Airport A, IT performance focused on the availability of a system because for the interviewees from IT and Operations, the most important indicators were availability measured against the number of outages and downtime, and the other indicator was response time (i.e. speed to recover). One of the biggest challenges for Airport A is to measure IT performance and the impact on business because IT is aggregated to other factors that impact airport performance. For example, the Number of Mishandled Baggage indicator, can be reduced with use of automated baggage reconciliation and tracking solutions. However, the improvement in performance in baggage handling cannot be solely attributed to IT because there are other factors such as airline connectivity, on-time performance records, resources, and training that contribute to the reduction of mishandled baggage cases. At Airport A, the BRS system is provided by one of the Ground Handlers, unlike other airports where the BRS is traditionally provided by the airport as part of their baggage handling operations.

Airport A uses traditional financial performance indicators such as Earnings Before Interest, Taxes, Depreciation and Amortisation (EBITDA) and profit after tax to measure the airport's performance; both of which are listed in the airport's annual report. The airport also uses an external indicator based on the Airports Council International Airport Service Quality ranking (ACI ASQ) to benchmark its performance against other airports in the region. Airport A also measures its performance based on service quality so in addition to the ACI ASQ, they also rely on several passenger surveys which cover measure feedback on the efficiency of the airport and services provided, and customer satisfaction.

Airport A does not use traditional airport performance indicators (e.g. WLU) to measure performance. According to the VP Operations, he considers that these indicators are assumed to be mostly used for academic purposes, with little or no relevance to operations. Instead airport operations use very specific operational indicators such as Waiting Time at Check-in, Waiting Time at Security / Waiting Time at Immigration. For example, 90% of the passengers should be handled within 10 minutes (queuing + processing). This service standard is imposed on airlines, ground handlers and other service providers.

Airport operations and IT also use Service Level Agreements (SLA) for system availability for the purposes of measuring IT performance. The reason for using SLA is that it is assumed that any disruption to a system will have an operational impact, and these are measured and tracked because in most cases SLAs incorporate financial penalties to the suppliers of those systems. The availability of the system varies according to its criticality, but on average, it is expected that systems will be available 99.5% of the time (excluding downtime for scheduled maintenance).

The interviewees from IT suggested the development of an outcome-based performance indicator that would look at the business outcome for deploying a solution. For example, availability of 99.5% is just a number, so if the system was down 0.049% it means that the system still met the performance level set. However, the real question is the scale of the impact on business processes during this down period. So, there is a need to align performance measures with

business processes. The aim is to determine the threshold of the business during any downtime and its outcome (i.e. business impact).

## **Summary**

For Airport A, as a hub airport in Southeast Asia, the IT culture factors (i.e. the role, importance and benefits of IT) that are most important are: the operational role of IT because as hub the airport must be operate efficiently and technology enables the airport to be more efficient through automation; the mission critical function of IT is also very importance because the airport relies on several mission critical systems that if they are not operational cause major disruptions with both financial and reputational impact. The cost reduction benefit of IT is important for Airport A because through automation and operational efficiency it can reduce costs.

Airport A is constantly improving its operations, and introducing new products or services to be ahead of the competition because it faces strong competition in Asia but also competition from airports in other regions. Airport A strongly believes that IT can be used as a competitive advantage.

The airport characteristics that define Airport A are their preference to use SLA as a performance measure; the availability of skilled resources is a challenge and most critical from an operations perspective.

Airport A measures airport performance based on financial health and terminal operations that include passenger satisfaction (ASQ) and Service Level Agreements (SLA).

Airport A considers that IT does play an important in the airport, and has a positive contribution to airport performance.



### 5.1.3 Case Study 2 – Airport B – transfer hub in Northeast Asia

Airport B, located in Northeast Asia, has a total accumulated capacity of 70 million passengers that can be accommodated in terminal space of 610,000 square metres. Over 100 airlines operate from Airport B connecting over 190 destinations 220 cities worldwide. The vision of the airport is to strengthen the airport’s position as a leading aviation hub, and a vital economic engine for the country.

Airport B ethos is to strive to exceed passenger expectations, in addition to foster a culture of innovation within the airport community. The airport is constantly innovating by introducing new services to facilitate transfer operations, which includes development of its intermodal transportation hub since this is a key to the airport’s growth.

The completed interviews were with six senior managers in IT, Operations, Commercial and Purchasing, namely the Chief Information Officer (CIO), the Director of IT, the General Manager Terminal Operations, the General Manager Airfield, the General Manager Retail, and the Deputy General Manager Procurement. The table below shows the total duration and recording time of the interviews.

Airport	Interviewee	Duration of the Interview (Hour)	Recorded Interview (Hour)	Remarks
Airport B	CIO	1:05:41	0:51:41	Additional 14 minutes were not recorded - offline discussions about IT and the Airport Strategy
	Director of IT	1:00:00	0:26:29	Technical problem with recording device
	General Manager Terminal Operations	1:04:18	1:04:18	
	General Manager Airfield	1:30:23	1:17:23	Additional 13 minutes not recorded - offline discussions about the airport and technology
	GM Retail	0:35:00	0:35:00	
	Deputy General Manager Procurement	0:45:00	0:45:00	
Total duration of the interviews		6:00:22	4:59:51	

## **IT culture – the role of IT**

What matters for an airport hub that is constantly innovating in the terms of the roles and contributions of IT (i.e. strategic, operational, custodian, and transformational) generated mixed responses from the interviewees. However, they all agree that IT has a low priority in playing a strategic role in defining the airport's strategic goals. The explanation that best describes their view is given by the GM Airfield who stated that IT is taken for granted as it is entrenched in everything that the airport does, for example, without an IT system such as a baggage handling system, the airport would not be able to operate. The same perception is also shared by some of Airport B's board members, who do not see the value of IT in steering the strategic direction of the airport. This is summarised by the GM Airfield: "the airport is building everything on IT but IT is not steering the direction the airport. Airfield Operations will run the system, and design the key performance indicators (KPI) that are built upon the pillar of IT".

All interviewees agree that the highest priority is the operational role, which is attributed to the use of IT to streamline and simplify processes, reduce errors through automation (e.g. baggage handling, automated boarding gates, and automated baggage drop), act as an enabler of the business. A shared view is that the airport is built upon the IT pillar and cannot do without it. The operational priority is also a result of the blending of technology, people and process because technology alone is not sufficient to deliver on its benefits (i.e. technology that brings automation, users to operate the system, and process that changes as result of automation).

The custodian role is defined as the responsibility for all IT matters of an airport including security and governance. For Terminal Operations, IT, Procurement, and Retail they are considered as high priorities because governance sets the framework on how an IT solution should be implemented. Also implementation is process-driven as it requires the IT Department to be closely involved in co-ordinating the activities of a project. For example, the implementation of an automated bag drop solution (i.e. check-in and acceptance of baggage without assistance of an agent) required the co-ordination between the airlines, ground

handlers and the airport to ensure the necessary changes in the process to monitor and assist passengers with excess baggage issues, or issues with the device. However, the CIO and GM Airfield do not attach the same degree of importance to the custodian role because in some cases, the responsibility of certain systems, like Airport A, remains within different departments; for example, it is common for other departments to engage with IT to offer support in the technology solution evaluation process (e.g. Baggage Handling System is under Airfield Operations). However, the IT department is involved in all aspects of the IT planning to deployment but not necessarily in managing the system.

The transformational role is high for all interviewees because when applied properly IT will have a bigger impact on operations delivering high availability systems. For example, when a system is said to have 99.95% availability in a year, it means the vendor guarantees that in a year the system (e.g. Common Use Terminal Equipment (CUTE) a shared check-in facility) would be operational for 8755 hours ( $(24 \times 365 = 8760) \times 99.95\%$ ). The transformational priority is linked to the operational priority, because it transforms airport operations through automation thus making it more efficient; for example, the deployment of Radio Frequency Identification RFID baggage tags to improve baggage reconciliation and reduce the number of mishandled baggage.

### **IT culture – the importance of IT**

The importance of IT has been classified into seven different categories: (a) mission critical to airport operations; (b) key to growth of the airport; (c) important to create new products or services at the airport; (d) to address the airport's needs in how to use technology; (e) to address the airport's technology needs; and (f) IT's contribution to airport performance.

For all interviewees, the mission-critical function of IT was considered as the most important because in the event of system failure the impact on airport operations could be considerable, which means it can stop the airport. An example of a mission-critical system is the Flight Information Display System (FIDS) that provides information not only to passengers but also to airline, airport and ground handling operational staff. Failure in the system means that departing passengers

will not be able to locate check in, the gates assigned for their flights, the status of the flights (i.e. on time or delayed), and arriving passengers will not be able to find their baggage collection belt. One example of the mission-critical function of IT, was the highly publicised system failure that caused major disruptions at the opening of Heathrow Terminal 5 (BBC, 2008). A malfunction with the baggage system resulted in almost 300 flight cancellations. According to the GM Airfield of Airport B, if his baggage system goes down 25%, which means approximately 4,000 bags an hour being impacted, his team would need to work to ensure that the remaining 75% of his baggage operation is still running. Therefore, the priority for his team is to avoid the complete stop of his operations.

The responses from interviewees regarding the importance of IT as key driver of growth appears to be at the medium-level because it delivers efficiency that enables the airport to grow and to handle more passengers but the growth is not a direct result of IT. The importance of IT in addressing the airport's training was considered high, and according to the GM Airfield, there is an expectation from the airport personnel that the new technology be user-friendly and intuitive to use which would require minimal levels of training. Although, a mix of traditional training methods (i.e. classroom training) and web-based training is provided, and that is where IT is heavily involved to ensure that web-based training is available for staff, particularly for Terminal Operations team.

IT also plays an important role in enhancing the airport's products or services and to meet the airport's need, a unanimous agreement from all interviewees. For example, the airport has equipped all front-line terminal operations staff with tablets that allows them to provide a better service to the travelling public from anywhere within the airport. The added value is that the technology is enabling the staff to be mobile and to access operational information (e.g. delays, gate changes) that can assist passengers, particularly during weather-related disruptions.

All interviewees considered very high priority for Airport B the contribution that IT has on airport performance because through the automation of processes, the airport becomes more efficient, frontline staff can provide a better customer

experience, ensuring the airport is operational and critical systems are performing (e.g. point of sales systems for retailers and concessionaires, passenger check-in systems, facilities systems, and security systems).

The General Manager Airfield Operations provided an explanation on how to elevate the importance of IT. This can be achieved, he argued, by stronger and improved positioning with the airport business. In this particular case, the challenge from management's perspective is how to optimise utilisation of the asset so that more passengers could be handled within a system that is capacity constrained. Therefore, one of the solutions to this problem was to reduce processing times for both passengers and aircraft, with IT playing a significant role in providing a solution that is cheaper and quicker than the alternative of doing nothing. However, making IT relevant to the business is about re-positioning itself by demonstrating its value to the business. For example, the contribution of IT will be to reduce the processing time from three minutes to 2.45 minutes giving the airport an additional capacity of 4 million passengers. Therefore, IT becomes relevant because it improves processing time, enhances the passenger experience, and increases system capacity.

### **IT culture – the benefits of IT**

Airport B considered the most important benefit of IT was its ability to improve decision making through being able to provide a platform for business intelligence. Airport operations, by their nature, involve complex inter-relationships between systems, data and stakeholders. Identifying relationships, patterns and trends that impact airport operations can be achieved by using data analytics applications that are applied to different data sources such as flight information, weather, passenger information, baggage data, as well as social media data. For Airport B's CIO, business intelligence was particularly important during disruption management on the normal day of operations, the airport can predict with good certainty what will happen throughout the day. But when there is weather disruption, system failure, or an aircraft incident, the predictive analytics capabilities of business intelligence system will be able to provide the airport with certain scenarios to mitigate the impact of these disruptions. For

example, in case of the failure of an automated people mover (APM), the impact of this could be mitigated by automatic audio announcements of the closure, and the provision of alternative transport, with the number of buses determined by the business intelligence system which uses current and historic flight information.

Two other benefits considered important by all interviewees was the need to use IT to enable the airport to do things differently and become more competitive, and to help reduce costs. Airport B, as a hub in Northeast Asia, faces intense competition from other airports, and as an important transfer hub, deploys technology to improve processes. For example, extending the passenger processing infrastructure to intermodal transport nodes (e.g. train stations, and ferry stations), which means passengers and their baggage can be processed at these nodes, thereby avoiding the requirement to check-in at the airport. The cost reduction benefits come from the automation of processes and capacity improvement. According to the GM Airfield, the airport has increased its terminal capacity by 55% without having to expand the terminal (i.e. without having to invest on building an extension to cope with increased volume of passengers).

Airport B faces shortages of manpower, and there is an expectation that IT will contribute by changing processes and potentially delivering greater benefits compared to labour-intensive processes (check-in or baggage handling). For example, changing the passenger check-in with the introduction of an automated bag drop solution combined the deployment of self-service check-in kiosks aims to reduce the number of check-in agents.

The CIO, unlike the other interviewees, considered the benefits of enabling product and service differentiation; and to bring and encourage innovation as being of medium-level importance. The explanation given was that differentiation is not the result of technology alone but a combination of infrastructure, processes, people and other factors. However, the CIO agrees that IT is important for Airport B and brings important benefits.

## **IT Investments and systems**

Passenger and Baggage processing, and Security were considered very important areas of investment for Airport B. The CIO's view is that these areas are considered very important due to the amount spent on enhancing these areas. According to the GM Airfield, the airport has spent over US\$100 million over a period of 5 years to improve the baggage processing system. Airport B has also been investing on improving passenger processing efficiency through the implementation of solutions that are more focused on self-service (i.e. check-in kiosks and automated bag drop). One area that was considered by all interviewees was investment in environmental initiatives, although important it is not the focus for these executives. Airport B also considered as fairly important the investment in areas such as runway operations, airport operations, and in Airport Collaborative Decision Making (A-CDM) to enhance the business intelligence capabilities of the airport. Investment in support functions such as Finance and Human Resources are important but these systems are stable and do not require the same level of investment as passenger or baggage processing systems. The IT investment to support commercial areas, according to the GM Airfield and CIO are important because of the importance of non-aeronautical revenues to the airport whilst the other interviewees did not comment on it. It was also mentioned by the CIO that ownership of Point of Sales (POS) systems for commercial activities vary from country to country, for example, for airports in China the POS is owned and managed by the airport operator because they are required to show proof of collection of tax of goods sold. So, Airport B, unlike airports in China, does not deploy a centralised POS to generate tax reports to comply with this government policy.

Further to identifying key investment areas, the interviewees were also asked about specific IT systems (i.e. Self-service, Resource Management, A-CDM, and Airport Management) and their impact on performance.

With regard to Self-service kiosks (i.e. self-service kiosks for passenger check-in), the airport deploys these units as a bespoke solution for an airline or as a shared common-use infrastructure. The interviewees from Operations and IT

agree that self-service has an impact on improving turnaround time by eliminating the need for counters which allows for faster passenger processing. Airport B does not have a specific KPI for self-service, as it is considered to be part of the indicator related to the check-in processing time, which combines agent-assisted and self-service check-in.

Resource Management Systems (RMS) are deployed to manage the allocation of the airport's fixed resources such as gates and parking stands. All interviewees agree that RMS has a positive impact on performance such as providing a capability to improve turnaround time. For example, an aircraft lands and is allocated a gate position but the gate is still occupied by another flight which has been delayed due to technical problems. As a result RMS, upon notification that the gate is still occupied, will automatically reallocate a new position for the aircraft that landed, and will notify all stakeholders (e.g. ground handlers, ramp, catering and fuelling) of the changes, thus reducing the impact of the change on turnaround time.

Airport B uses an Airport Collaborative Decision Making (A-CDM) tool, where key stakeholders (i.e. airport, airlines and Air Traffic Control) share information in real time to make fast operational decisions. Within the airport, the system is managed by the Civil Aviation Department which is also responsible for air traffic control services. Therefore, the airport interviewees could not comment on A-CDM. Although A-CDM is still in its early stages of implementation at Airport B, the GM Airfield believes that the key to its success lies in the integration of the users' expectations of the benefits, the value it brings to the community, and most importantly, how they collaborate as a community. The community and collaboration aspect of A-CDM was also brought up by the CIO who believes that technology is not an issue, but creating a culture of collaboration and information sharing is at the core of an A-CDM solution.

Airport Management Systems (AMS) are essential to supporting airport operations. The main component is the Airport Operational Database (AODB), and the interviewees consider this to be an important system but as mentioned



by the CIO, the database is not expected to improve performance because it functions solely as a data repository.

With regards to procurement, this is undertaken at Airport B by a department that has responsibility for all procurement activities including responsibility for the policies, procedures and compliance. However, in the case of large infrastructure projects, a subdivision of the procurement department will be created because it does not possess sufficient internal capability since large-scale projects tend to be highly complex requiring very specific specialties such as civil engineering works. In the case of procurement of IT solutions, the design specifications and requirements are provided by the IT department who act in an advisory role working closely with the department that is procuring the solution.

### **Airport characteristics and its marketplace**

The interviewees were asked about their management preferences related to the use of Service Level Agreements (SLA) to measure airport performance, the availability of resources and the use of outsourcing, and the competitiveness of the airport environment.

All interviewees strongly agree that SLA is an important tool in measuring airport performance. Airport B names their SLA as Airport Service Targets, and in addition to SLA they also use the Airports Council International (ACI) Airport Service Quality (ASQ) measures. The GM Terminal Operations believes that in addition to monitoring the agreed targets it is equally important to be able to resolve, in a collaborative manner, the problems preventing stakeholders meeting their targets. For example, the build-up of a queue or longer queuing time at immigration; the solution is to share information about the arrival patterns of passengers and match sufficient manpower to meet the surge in arriving passengers. This could only be addressed by adopting a multi-stakeholder (airlines, airports and Immigration services) approach to find a solution.

Airport B also uses SLA related to Passenger Processing time, and Baggage Processing, mostly for arrival bags (e.g. first bag on the belt within 20 minutes after landing). However, all interviewees do not consider SLA for aircraft

processing as relevant to their operations because there is already an agreement between the airline and their ground handler in terms of meeting turnaround time (e.g. ramp handling, catering, cleaning, fuelling and maintenance) targets.

All interviewees strongly agree that outsourcing is used by Airport B to cover the shortage of non-core internal resources such as trolley management, and cleaning. Additionally, outsourcing is used to reduce costs through the transfer of business risk, resources and assets to another company (e.g. IT maintenance). The consensus among all interviewees is that skilled resources are important to achieving high performance, and most of them were neutral regarding the availability of skilled resources as it depends on the skills being required. However, a dissenting view from this was expressed by the GM Terminal Operations who considered that there are skilled resources available in their area because they have a strategy of continuously hiring fresh university graduates with a career path to develop their leadership and management skills.

The interviewees' responses to the question about the competitiveness of the market place was mixed with IT. However, the GM Terminal Operations and the GM Airfield hold largely different opinions on competitiveness. However, they both acknowledge the importance and relevance of airport competition. Both believe their airport competitors are different in the way they operate, with their own strengths and weaknesses, and the airport cannot be complacent, and for this reason Airport B is constantly innovating to be "ahead of the curve". Therefore, deploying new products to deliver better services to their passengers is key to their strategy but it is not driven by the competition (i.e. they will not follow on other airport's footsteps) but instead the airport considers the introduction of new products and services as part of their self-improvement process. And with regards to the use of IT as a competitive advantage, the responses have been mostly neutral because despite investments in new systems and technology the relationship with competitiveness is not immediately or visibly apparent. For example, the investment in providing free Wi-Fi connectivity has been achieved at a cost to the airport but whether it has given it

a competitive advantage is not clear because passengers today expect to have Wi-Fi provided by the airport as a free service.

### **Performance measures**

This section provides the views from the interviewees of Airport B regarding the performance measures used by the airport. And to understand how Airport B measure's airport performance. Their responses are grouped into the following categories: what is measured, the performance indicators, and how IT performance is measured.

Airport B measures performance based on terminal operations and passenger satisfaction, in addition to safety and security (e.g. rate of airport staff and passenger injuries at the airport) which are communicated in its annual report. This is summarised by the representatives of IT as the airport's key performance pledges: Safety (e.g. with over 65,000 people working at the airport – safety is paramount to management), Secure (e.g. process and systems that support airport security such as Closed Circuit TV – CCTV are always available), and Smooth (e.g. ensure a seamless passenger journey from the moment the passenger arrives at the airport to boarding the flight).

The airport also uses other performance indicators such as ACI Airport Service Quality (ASQ) for passenger satisfaction (ASQ), and an additional 34 operational Key Performance Indicators (KPIs) covering the different stages of the passenger journey such as satisfaction with transportation, car park, signage, check-in time, and facilities. For example, first bag to be delivered within 20 minutes of an aircraft landing, passenger processing at check-in (92% of passengers to be checked in within 12 minutes), security queue with 95% of passengers processed within 4.5 minutes and immigration within 15 minutes. From an IT perspective, Airport B measures their performance based on system availability (e.g. availability of 95%) linked to Service Level Agreements between vendors and airport. The CIO also indicated that the airport has also adopted a new corporate indicator, which is linked to corporate social responsibility (e.g. financial donations, and greenhouse emissions).

**Summary:**

For Airport B, the IT culture factors that are most important are: operational role of IT to improve the efficiency, the mission critical importance of IT, and the benefits of IT is to improve decision making, a benefit delivered by business intelligence that helps the airport to find data relationships, patterns and trends that have an impact on airport operations by applying analytics on different data such as flight information, weather, passenger information, baggage data, as well as social media data. With business intelligence, the airport can predict what will happen throughout the day.

Technology is also enabling the Airport B to deal with the airport's manpower shortages, which is being addressed through automation of labour-intensive processes (e.g. passenger check-in) through the introduction of self-service, reducing manpower from the check-in, and at the same time improving the customer experience by giving them control of the process. However, the airport strongly believes that the benefits of IT cannot be delivered through technology alone but requires the airport to change its processes, and people's (i.e. users) acceptance and adoption of technology, which will then deliver the full benefits of technology.

Airport B as an important transfer hub faces intense competition from other airports, and technology is used to improve processes not only at the airport but also at intermodal nodes that feed traffic to the airport. Airport B believes that with technology the airport increased its terminal capacity by 55% without having to expand the terminal infrastructure.

The airport characteristics that define Airport B are their preference to use SLA to measure performance, skilled resources are important to achieve high performance. Although the airport believes in strong competition, they do not follow the competition, that is their product/services strategy is not driven by the competition, but as part of their own self-improvement strategy to stay ahead of the competition. There is no consensus at Airport B on the competitive advantage of IT, for example, the introduction of RFID bag tags made transfer operations

more efficient, but it is not clear whether it has given the airport a competitive advantage.

Airport performance measures are based on terminal operations and passenger satisfaction with well-defined performance indicators. The airport also uses ACI ASQ to measure the satisfaction of passengers. And recently the airport adopted a new corporate indicator to measure their corporate social responsibility.

Airport B considers IT to play an important role in airport performance because of the benefits delivered through automation.

### 5.1.4 Case Study 3 – Airport C – international airport in Australia

Airport C, located in Australia, has a planned capacity of over 70 million passengers. Over 45 airlines operate from Airport C connecting over 100 destinations in over 25 countries. The airport has a strong focus on continuously improving and developing as a hub.

Passenger experience delivered through operational efficiency is key to deliver on their vision of world-class airport. The airport faces a number of constraints to their operations (e.g. curfew) and relies on technology and innovation to minimise their impact.

The four completed interviews were with senior managers in IT and Operations, namely the Head of IT, Head of Operations, Head of Service Delivery, and Head of Strategic Planning. The table below shows the total duration and recording time of the interviews.

Airport	Interviewee	Duration of the Interview (Hour)	Recorded Interview (Hour)	Remarks
Airport C	Head of Service Delivery	1:00:47	1:00:47	
	Head of IT	1:06:01	1:06:01	
	Head of Strategic Planning	0:45:00	0:29:00	Additional 16 minutes not recorded - offline discussions about the airport and technology
	Head of Operations	0:45:00	0:45:00	
Total duration of the interviews		3:36:48	3:20:48	

#### IT culture – the role of IT

Airport C relies on technology to address their business needs to continuously improve efficiency. Hence, the interviewees were asked to define whether the orientation of IT is strategic (i.e. defining the strategic goals of the airport), operational (i.e. to improve the operational efficiency), custodian (i.e. responsible for all IT matters of the airport), or transformational (i.e. to transform the airport through the deployment of technology). The interviewees stated that the highest role of IT at the airport is the operational role, followed by transformational,

custodian, and the lowest priority is the strategic role because the strategy role actually sits outside the IT domain which does not influence the strategic direction of the airport. For the Head of Strategic Planning, IT is an enabler to the business and it does not influence or set the strategic direction of the airport. For example, big data is a technology trend that will change the way businesses operate with improved decision-making through analytics. However, big data will not influence the strategic direction of the airport. Instead IT will help enable the airport to achieve one of its strategic priorities such as improving its customer focus and orientation.

For the Head of Operations, the priority was considered medium because they do not consider IT as the main driver to operational efficiency because there are other factors that contribute to the efficiency of the airport. However, for the Head of Service Delivery, IT is a key enabler for the customer-facing staff to deliver a high-quality service to their customers. The other reason for the highest priority for the Service Delivery team was the significant shift from manually performed tasks to automation. For example, baggage systems, check-in, automatic boarding gates, all help the team to focus on delivery of services instead of being “distracted” by manual processes (i.e. once the process is finished, for example, check-in, then the attention reverts to the passenger).

The transformational role was considered a high priority for the interviewees because of the airport’s move towards automation. According to the Head of Operations, IT can change the way airports function both operationally and from a customer/passenger’s perspective.

At Airport C, IT is not centrally managed, which means other departments will have IT solutions that are managed within their department. For example, security systems are managed by the Security Department. Therefore, the custodian priority is low according to the Head of Operations, and medium priority for the Head of Service Delivery. Despite some of the systems being under the responsibility of different departments, they still need to work closely with IT. An example given by the Head of Service Delivery is that once the system is implemented there is a need to change some of the business processes. This

forces their department to innovate in order to make sure they get the best of that implemented IT system.

### **IT culture – the importance of IT**

The interviewees of Airport C were asked why IT was important to them, and they have been asked to rank the importance of IT based on the function it plays: (a) mission critical to airport operations; (b) key to growth of the airport; (c) important to create new products or services at the airport; (d) to address the airport's needs in how to use technology; (e) to address the airport's technology needs; and (f) the contribution IT has on airport performance.

All interviewees considered the mission-critical function of IT the most important, and for the Head of Service Delivery, systems such as the Common Use Terminal Equipment (CUTE) a shared check-in solution, and the baggage handling system are very critical to operations, and for these systems not to be operational would be a disaster for the airport. The other function considered very important for all interviewees was the deployment of IT to enhance product or services because through automation Airport C is able to deliver better services (e.g. customer service enhancement), increasing airport capacity through technology (e.g. shared services for check-in), and to provide new services (e.g. Wi-Fi services). For the Head of Service Delivery, their ambassadors (i.e. volunteers to assist passengers) improved service to customers as result of moving from a largely paper-based system toward tablets, so that they can automatically access operational information using these devices instead of extracting information through traditional manual processes (e.g. phone calls, paper printouts). So IT, in this respect, acts as an enabler to enhance a service.

The IT role as an enabler of growth (key to growth of the airport) was considered of high importance by both the Head of Operations and Head of Service Delivery because it enables the airport to expand its constrained terminal capacity through the deployment of technology such as end-to-end self-service solutions for check-in, baggage drop, and automated boarding gates, which means increased terminal capacity and less staff required for check-in and boarding activities. For example, using 2 automated boarding gates and 1 manual gate, a B747 with 300



passengers could be boarded in 10 minutes compared to a planned 30 minutes for boarding. However, for Head of IT and Head of Strategic Planning, they considered this factor to be of medium importance because from their perspective, growth is a function of demand and IT enables the airport cope with growth.

The interviewees considered as of medium importance the IT function to address the airport's technology needs because it is embedded in all processes, and as a result its value is underestimated. Yet for the Head of IT the function of IT is an important one because of the airport's high dependence on IT systems for it to run.

The IT function considered of low importance for all interviewees was in addressing Airport C's training needs because despite the move towards automation, very few are online or web-based training, which according to the Head of Service Delivery is very disruptive since rotas have to be changed to allow for face-to-face class-room instruction.

All interviewees agreed IT plays an important in role in the airport, as explained by the Head of Strategic Planning. IT has a high level of control over the airport. For the Head of Service Delivery, IT underpins everything at the airport and the systems are used to the best of advantage to deliver the result through people. For the Head of IT, the IT Department ensures availability and reliability of systems so that others can deliver their services; and for the Head of Operations, IT has the potential to significantly improve service and operational efficiency. And for those reasons, all interviewees also agreed that IT has high and had a positive contribution to the performance of the airport.

### **IT culture – the benefits of IT**

The last factor of IT culture is the benefits of IT to an airport, that were classified as: (a) to enable the airport to do things differently and become more competitive; (b) to reduce costs; (c) to improve decision making through business intelligence; (d) to enable product and service differentiation; and (e) to bring and encourage innovation. Airport C considered as very important benefit of IT to improve

decision making through business intelligence. For the Head of Service Delivery, they considered it very important but he also explained that the airport has not yet fully realised its benefits from their business intelligence project. For this reason, the Head of Strategic Planning considered IT an important benefit, since they could not see the results or any measurable outcomes just from the business intelligence project.

The benefit of IT was to do things differently and become more competitive was considered very important for the Head of Operations and Head of Service Delivery because it enables the airport to transform the way the airport is run and managed. For example, service standards have improved because new tools were introduced that enable the airport to measure and monitor performance (e.g. queuing time) and ensure compliance with agreed service standards. For the Head of IT and Head of Strategic Planning this benefit was considered fairly important. However, all interviewees agreed that increased competitiveness is the result of better use of the infrastructure to improve the passenger experience.

The economic benefit of IT (i.e. to reduce costs) was considered fairly important for all interviewees. The Head of Operations considered that the benefit of cost reductions is the result of the airport being operationally more efficient through automation, and maximising the use of infrastructure to delay expansion by deploying a shared infrastructure (e.g. Common Use Terminal Equipment – CUTE), and better resource utilisation (e.g. automated allocation of resources such as gates and parking bays).

Airport C considered innovation an important benefit of IT, and the airport has a well-defined digital transformation strategy that includes the introduction or trial of innovative solutions such as the deployment of permanent baggage tags for passengers, and automated bag drop solutions. The Head of Service Delivery believes that Airport C is trying to push the innovation boundaries, unlike most airports in Europe and USA, who appear to be more conservative when it comes to the adoption of new technology. The innovation process is also a collaborative one as it requires working closely with an airline to deliver on some of those

innovations, especially when they are related to passenger and baggage processes.

And the last of the benefits of IT (i.e. to enable the airport differentiate its products and services) was considered fairly important for all interviewees except for the Head of Strategic Planning, as he considered it to be slightly important because there is little that can be differentiated. For example, any airport has to provide a place where passengers are checked-in, which means a desk with a scale and a baggage belt to inject the baggage into the baggage handling system, and in case of a shared infrastructure, the desk will also have a computer, phone, and printers for the boarding pass and baggage tags. However, the other interviewees argue that the process can be differentiated through the introduction of self-service solutions to improve the check-in process (e.g. self-service kiosks and automated bag drop). For the Head of IT, the introduction of these new services was an important differentiator when compared to other airports in Australia and Asia.

### **IT Investments and systems**

The interviewees of Airport C were asked to identify the key IT investment areas, classified in: (a) Passenger and Baggage processing and related services; (b) Runway operations; (c) Airport Operations (e.g. Resource Management Solution to manage resources and schedules); (d) Environmental Initiatives (e.g. energy efficiency, waste management, and other related activities); (e) Airport Security (e.g. identity verification, and employee access to restricted areas); (f) Business Intelligence (e.g. data analytics, and A-CDM); (g) Business Support systems for Finance and Administration (e.g. Enterprise Resource Planning solution); and (h) Commercial systems (e.g. Point of Sales solutions for retailers, and Car Parking solutions). All interviewees stated that the most important investment area was in the Passenger and Baggage processing and related services. The investment focus, according to the Head of Service Delivery, has been on improving passenger processing efficiency through the deployment of self-service solutions that also includes automated bag drop.

Investment in Business Intelligence was also considered very important by the interviewees, except for the Head of Strategic Planning who considered it to be

less important because the benefits have yet to be realised. It is important because it will provide considerable insight such as customer segmentation, buying patterns, on-time performance monitoring, queue and waiting time monitoring, service level management, that will be easily accessible through reports and visualised in operational dashboards. Therefore, business intelligence will become a critical operational system for the airport, and the reason for being considered as being a very important investment area.

IT investment in Runway Operations is a very important area according to the Head of Operations and Head of Strategic Planning because of the OneSky (i.e. Airport Collaborative Decision Making – A-CDM) project driven by Airservices Australia to improve operational processes such as transfer planning, gate allocation, and runway and capacity planning, which is expected to benefit the airport community (e.g. airport, air traffic control, airlines, and ground handlers).

Airport Operations as an investment area was considered very important for all interviewees, especially for the Head of Service Delivery because without some of the key systems (e.g. Resource Management System or Flight Information Display System) they would not be able to operate as effectively.

Security was considered fairly important area of investment for all interviewees, and according to the Head of IT, the investment is towards identity verification, access control system, and security monitoring (e.g. Closed Circuit TV – CCTV).

Investment in Environmental initiatives was considered important for all interviewees, and from Strategic Planning perspective there are stringent State and Federal environment regulations that the airport has to comply with specially with regards to curfew and noise abatement procedures. As part of the investment in these areas, solutions are available that can bring better building management systems to manage and monitor energy consumption and conservation, plus lighting.

Business Support systems (e.g. financial systems, human resource systems) and Commercial systems (e.g. Car Parking system) were important areas of investment. However, the Head of IT clarified that Commercial systems are the

responsibility of the concessionaires (retailers or car parking operators), So in this case the airport has no control over the investment. The IT department also works closely with the car parking operator because it is an important revenue generator for the airport, and the collaboration between the two organisations is designed to optimise the use of car park.

Airport C has identified key investment areas, and was subsequently asked to provide information on specific systems and their impact on reducing aircraft turnaround.

Self-service (i.e. self-service kiosks for passenger check-in) was not deployed to improve aircraft turnaround but to improve the congestion problems of the airport. However, self-service could help on-time performance and aircraft turnaround as it improves an airline's efficiency in terms of passenger handling, which would potentially result in faster passenger processing times. Although Airport C does not use specific KPIs, a few were suggested such as passenger experience, passenger feedback and queuing time.

Airport C used an automated Resource Management Systems (RMS) to manage the airport's fixed resources such as gates and stands. The deployment of RMS helps Airport C to improve operational efficiency through optimisation of gates and parking bays, which in turn improves aircraft turnaround. For the Head of Service Delivery, the introduction of an automated system was a big step change for the airport, and the next step for the airport is to integrate all resources of the airport (e.g. airlines' and ground handlers' resources and equipment) into a single platform, which would be the "ultimate" or "ideal" operational system providing visibility of all available resources (e.g. gates, staff and equipment). No KPIs are used, but the following are recommended: stand utilisation and number of aircraft per stand per day.

Airport Collaborative Decision Making (A-CDM) is part of project driven by Airservices Australia, and all interviewees agree that it is one solution that has the biggest impact on improving aircraft turnaround, and it is strongly linked to improving airport efficiency. However, according to the Head of IT, it is a long journey and a complex project because for it to be successful, it requires all

airlines operating at the airport to be integrated and to cooperate in providing data into the system. Full cooperation between all stakeholders has yet to be achieved at the airport to make this work.

The procurement of IT solutions by Airport C is monitored and controlled by the finance department, which is part of the airport's policies and procedures. As explained by the Head of IT, any department who wants to procure an IT system (i.e. effectively the budget owner) goes to the Finance department and explains what is to be procured, and in return Finance generates a template that needs to be completed. The content of the template is used to generate a tender document. The tender process is managed by the department which raised the procurement request. At Airport C, IT procurement is decentralised, which means each department is responsible for their own purchasing requirements since they own the budget with the IT department providing support by ensuring that business needs are met by the solution to be procured, and to specify these requirements as part of the tender documentation preparation process.

### **Airport characteristics and its marketplace**

The interviewees were asked to describe the management preferences related to the use of Service Level Agreements (SLA) to measure airport performance. The interviewees agree that SLA is an important element by which to measure airport performance. The Head of Service Delivery believes that although it is useful, care must be exercised when setting the metrics to make sure that it is applicable throughout the year and it is relevant for the different operational periods (e.g. peaks). As for the Head of Strategic Planning, they are not in favour of having SLA related to airport performance because it can be affected by many different factors. The SLA should include targets that are aspirational where both entities try to achieve them, and it should be used more for planning facilities than for a purely operational purpose (e.g. deterioration of waiting times as result of constrained resources or infrastructure).

The interviewees also agree that IT solutions are procured to ensure Service Levels are maintained, and the use of queue monitoring solutions is one such example. However, the Head of Service Delivery disagreed because the focus is

not to procure systems or solutions to maintain SLA, but they are procured to address specific issues such as congestion. Congestion is addressed by the airport seeking information about the problem. So monitoring queuing time provides one set of data to include in the analysis.

The interviewees did not have a strong opinion about the use of SLA related to Passenger, Baggage and Aircraft processing. For the Head of Strategic Planning their reason was not knowing if there are SLAs in these areas, although they recognise the importance of having SLA in these processing domains. For the Head of Operations and Head of Service Delivery because there are no formal SLA but informal agreements between airport and airlines, these are aspirational ambitions. The airport is working towards the implementation of SLA, which explains the nature of their responses. As part of the work to implement relevant SLA, the airport is working on mapping the ACI ASQ (Airports Council International Airport Service Quality) scores Service Level measures so that the airport can improve their ASQ ranking by being able to monitor specific core measures of the service level that influence the ASQ scores (e.g. waiting time at check-in queue).

All interviewees agree that outsourcing is used by Airport C not only to deal with a shortage of internal resources but also to deal with specialised tasks such as Airport Security Screening, which is an outsourced function. The Head of Service Delivery also explained that they can bring casual staff to cover shortages particularly during peak periods (e.g. end year holiday season). The consensus among all interviewees was that skilled resources are important for the airport to achieve a high level of performance. However, when asked about the availability of skilled resources in the market place, the responses varied with IT, Strategic Planning, and Operations agreeing with the above statement mostly because skilled resources can be poached from airports in Australia and in the region. However, the Head of Service Delivery disagreed that staff resources with knowledge of the aviation industry are readily available; there are lots of semi-skilled resources available for tasks such as moving bags, general electricians and other skills, but not with a strong knowledge of the industry.

According to the interviewees of Airport C, they all agreed that there is competition in their market place. From the Strategic Planning perspective, the airport competes with airports within Australia; they do not see themselves competing with airports outside Australia or large hubs such as Singapore, Hong Kong, Narita or Dubai.

The interviewees did not have a strong opinion about the airport bringing new products or services due to the competition. For the Head of Service Delivery, the introduction of new products or services is driven by the airport's business needs such as constrained infrastructure. However, according to the Head of Strategic Planning, it does not mean that the airport is not monitoring what the other airports are doing, and the airport tries to keep up or stay ahead of the competition. The Head of Strategic Planning strongly agrees that IT is used by Airport C to secure competitive advantage. However, this opinion was not shared by Head of Operations and Head of Service Delivery who disagreed because airlines will not consider the IT infrastructure when assessing an airport to fly to. But the airline will do an assessment of airport facilities that includes the IT infrastructure, and the overall services provided by the airport. The outcome of the assessment is that the airport's facilities and services that can support the airline's operations so the competitiveness of the airport is not only due to IT.

### **Performance measures**

To understand how Airport C measure airport performance, the interviewees were asked to consider the following: what is measured, what the performance indicators are, and how they measure IT performance.

Airport C measures its performance based on terminal operations, financial health, and safety. The key performance indicators used by the airport are: shareholder value (EBITDA, share price and dividends), passenger satisfaction (ASQ), asset utilisation (e.g. number of times an aircraft uses the stand), queue time, inbound and outbound processes (security, check-in, bays and bay management).



For the Head of Service Delivery what is important is not only having the indicators but understanding what the outputs mean. For example, one check-in counter processes 30 passengers in an hour while another counter process 15 passengers. So, the key is to determine what is driving this difference in performance (e.g. location of the counters, check-in agent lack of training). Another example, was a self-service kiosk that during a specified period processed 800 passengers while another kiosk during the same period processed only 80 passengers so the analysis was carried out to determine if the problem was a hardware issue, location of the kiosk, or adjacent queue build up blocking the access to the kiosk. The point being made by the Head of Service Delivery was taking the numbers alone does not help the airport to improve performance, it also requires analysis of the information generated by the indicators. Therefore, the selection of indicators must be carefully considered to ensure that the airport is measuring what is relevant to the business.

The airport is also trying to take a holistic approach to measuring performance, for example, passenger processing encompasses all the different touchpoints of the process, the stakeholder/owner of these touchpoints (e.g. check-in, security screening, and immigration), and to optimise them. Once the process has been optimised the next step is to determine which performance indicators will be used to satisfy each of the stakeholders involved in the process. By taking the holistic approach the airport and the stakeholders will have a view of the entire process as opposed to discrete steps within the process. For example, check-in and immigration checks are speedily completed whilst the same passengers having to endure lengthy delays in a security screening queue. So, the measure not only focussed on check-in and immigration processing time but included security screening, thereby providing a view of the entire process.

Airport C measures IT performance based in system availability measured with standard IT Service Level Agreements such as system availability and the number of incidents. The biggest challenge from the Head of Service Delivery is that the availability metrics do not provide an accurate picture of the events because what matters for operations is when the system is not available and the

impact it has on operations and airline satisfaction. The 0.1% failure is what people will remember and not the 99.9% availability of the system.

### **Summary:**

The IT culture factors that are most important to Airport C are operational role of IT, the mission critical importance of IT because of the dependency of the airport on key systems such as baggage handling, shared check-in infrastructure and operational systems, and the most important benefit of IT is to improve decision making through business intelligence.

One of the main contribution of IT to Airport C is the improvement of service standards as result of the introduction of new tools or solutions to measure performance (e.g. queuing time) that ensure stakeholders involved in the process of delivering a service to the customer comply to these services standards, and are measure using an automated tool. Airport C is an airport that has a clearly defined digital transformation strategy to introduce or trial innovative solutions.

Airport C believes that competition is coming from other airports in Australia as opposed to competition from airports in Asia, and IT can be used as a competitive advantage through the deployment new products or services (e.g. self-service and automated bag drop). Airport C also believes that a competitive advantage is more than just technology. An airline will not choose Airport C because it has the latest technology, it might help, but it is not necessarily the main driver.

The airport characteristics that define Airport C are the preference to use SLA for measure performance. However, this is an aspirational ambition because the airport does not have operational SLA (i.e. passenger and baggage processing) in place with exception of IT SLA because IT systems have an SLA built in the contract. Airport C has a project to create SLA mapped against the Airport Service Quality (ASQ) indicators to monitor and improve ASQ scores. And the other characteristics is that skilled resources are important to a high performing airport.

Airport Cs performance measures are focused on financial performance, as well as terminal performance including passenger satisfaction (e.g. ASQ) along with

asset utilisation and queuing time. Airport C's preferred approach to measure performance is to take a more holistic approach, with performance indicators for all stakeholders along the different touchpoints of a passenger and baggage journey being included. Because they believe that outperforming during the check-in process but underperforming at security screening touchpoints, will have an impact on the passenger experience. Therefore, performance levels should be maintained consistently along the entire passenger journey, and not just in isolation of the various steps or touchpoints along that passenger journey at the airport.

Airport C considers IT to play an important role in the performance and has a positive contribution to airport performance because IT underpins every aspect of the airport, and without IT the airport would not operate.

### 5.1.5 Case Study 4 – Airport D – medium sized hub in Europe

Airport D, located in Europe, has a total accumulated capacity of 30 million passengers that can be accommodated in terminal space of 240,000 square metres. Over 70 airlines (including charter airlines) operate from Airport D connecting 169 destinations in 60 countries.

Airport D’s main strategic direction is set on three pillars: constant development of the airport as high-quality transport hub; exploration of commercial services to generate profits; exploiting new opportunities by leveraging airport skills to projects at local and international levels.

Two senior executives from Airport D were interviewed, namely Head of Airport Operations, and Head of Information and Communication Technology (ICT). The table below shows the total duration and recording time of the interviews.

Airport	Interviewee	Duration of the Interview (Hour)	Recorded Interview (Hour)	Remarks
Airport D	Head of Airport Operations	1:05:42	1:05:42	
	Head of ICT	1:20:32	0:54:32	Additional 26 minutes not recorded - offline discussion about the airport and technology
Total duration of the interviews		2:26:14	2:00:14	

#### IT culture – the role of IT

Amongst the four different roles played by IT (i.e. strategic, operational, custodian, and transformational) the interviewees from Airport D agreed that the highest priority is the custodian role, where IT is responsible for all technology matters of the airport business, including security and governance. The explanation for this high priority is because the airport needs all systems to run as smoothly and reliably as possible. Without IT the airport would not function due to the level of automation and reliance on systems (e.g. check-in systems, air-conditioning systems, and security systems). The lowest priority is the

strategic role; so, IT does not play a significant role in defining the Airport D's strategic goals. However, IT may have a role in supporting the strategic goals, which is in the deployment of what is the most appropriate infrastructure and technology to continuously develop the airport as a transportation hub.

The operational role was considered as a very high priority for the Head of ICT whilst for the Head of Airport Operations considered it as being between very high and high. Nonetheless both agree that the high priority can be attributed to the use of IT to improve the operational efficiency of the airport. The area that they consider to be of greater importance was operational efficiency, more specifically the adoption of the Airport Collaborative Decision Making (A-CDM) solution, which optimises aircraft departure management performance (i.e. from touchdown to take-off) resulting in increased capacity through being able to facilitate additional movements during peak hours. For the airlines, benefits can be realised, for example, reduced fuel and delay-related costs.

The transformational role is considered to be a high priority for the Head of ICT. However, this was considered to be of medium importance to the Head of Airport Operations because there are factors beyond technology (i.e. IT) that are needed to transform an airport. In his opinion IT supports or enables transformation but does not lead it. For the Head of ICT, IT does transform the airport by making it more efficient through for example, the ability to automate certain processes such as passenger check-in. They also added that for IT to transform an airport, this requires support from the project owners (e.g. operations or engineering) and end-users to ensure that IT delivers on the benefits of efficiency and automation.

### **IT culture – the importance of IT**

The interviewees of Airport D were asked to consider the importance of IT that was classified in seven categories: mission critical to airport operations; key to growth of the airport; to create new products or services at the airport; to address the airport's needs in how to use technology; to address the airport's technology needs; and the contribution IT has on airport performance. And for both the Head of Airport Operations and Head of ICT, the mission-critical function of IT was considered the most important function because if certain IT systems (e.g.

baggage handling system) are not working for about 60 to 90 minutes it can shut down the airport. Therefore, the design of the IT solution is important to avoid single point of failures, ensure availability and back-up plans. They both agree that IT has low importance as a contributor to the airport growth because their argument is that passengers do not choose to fly to and from Airport D based on the IT systems of the airport but on the overall facilities of the airport. The Head of ICT qualified their answer that the systems they supply, for example to reduce queuing time, help the airport to deliver better quality services.

The capabilities of IT to enhance products and services was considered high by both interviewees; medium importance in addressing the airport's training needs, and the airport's organisational needs because IT plays a supporting role to other departments' needs. Both interviewees consider IT to be of high importance to airports, because of its mission-critical function. With regards to the contribution of IT to airport performance they gave different responses. For the Head of ICT, the contribution is high because they are the base for the good performance of the airport. While for the Head of Operations it has medium importance because IT is only an enabler to his business. The Head of Operations considers IT to be the backbone of the airport (i.e. the infrastructure) to deliver the airport's products and services such as a fully automated baggage sortation and baggage reconciliation services to airlines.

### **IT culture – the benefits of IT**

The Head of Airport Operations and Head of ICT were asked to select the expected benefits of IT to enable the airport to do things differently and become more competitive; to reduce costs; to improve decision making through business intelligence; to enable product and service differentiation; and to bring and encourage innovation. Amongst these five benefits, the most important benefit was business intelligence because it entails sharing information and mining information. Airport D has a business intelligence project to be deployed across the airport organisation. One other benefit of this business intelligence project is the possibility of automation and integration of data because in the past the airport used manual forms (e.g. spreadsheets) and a mix of other systems to be able to

analyse the information available. One of the objectives of the business intelligence project is to create a corporate portal for all Key Performance Indicators (KPIs) that would also enable to drill down to the details of each KPI (e.g. Immigration queuing time and determine reasons for underperformance).

The IT innovation benefits were considered as fairly important by both interviewees because the technology innovation improves their operations. For example, to increase the passenger processing capacity the innovation focus has been on automated bag drop. Airport D was also one of the first airports to introduce video analytics to measure queuing times or queue length that helps to count the number of people in queues, waiting times in front of security controls and check-in. Airport D describes itself as a “fast follower<sup>27</sup>”, which means once the innovation has been tested by some other airport then they will act upon it, an approach adopted by many airports. The airport has also a preference for proven technology for mission critical areas, and reiterated that being innovative should be related to bringing efficiency to the business because the adoption of leading edge technology may come with a high risk to the business.

The benefit of enabling the airport to do things differently and become more competitive, was considered fairly important for the Head of Airport Operations. Because by improving passenger processing, they can delay any very costly terminal expansion plans. They can instead spend funds on improving facilities within the existing areas. However, for the Head of ICT, it was considered important, because it is a combination of IT, processes and people, that will deliver benefit.

The interviewees considered cost reduction as an important benefit to the airport. However, they both emphasised that cost reductions cannot be achieved at the expense of quality. For the airport, quality is very important and at the core of the business, therefore, the differentiation of product and services is delivered

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<sup>27</sup>This is a term used by AT Kearney in reference to Roger's bell curve of the technology adoption lifecycle with five categories: innovators, early adopters, early majority, late majority, and laggards. A “fast follower” is one that learns from early adopters before themselves venturing into using something new.

through quality, which is why they considered this benefit as being important. IT will help deliver a high-quality service for example by ensuring system availability (i.e. no service disruption) or providing a faster journey through the different processes (check-in, bag drop, immigration, and security).

### **IT Investments and systems**

The Head of Airport Operations and Head of ICT of Airport D when asked about the areas they considered important to IT investment areas, they both considered as very important the investment in Business Intelligence because this is Airport D's strategic project as mentioned by the Head of ICT as part of his response to the question about the benefit of IT. One fairly important area of investment also agreed by both interviewees was in passenger and baggage processing and related services. However, the focus is on the improvement in baggage processing with a project to expand the baggage handling area. The airport has also been investing in automated bag drop solutions aimed to speed up the processes for business travellers and passengers on short-haul flights.

The investment areas considered important were two: (1) airport operations because they both considered the airport to have a quality system in place to manage schedules and resources. The airport is continuously improving, where the focus is to invest to maintain the quality of the system through introduction of new features or upgrades. And (2) commercial systems but only related to car parking systems because of the importance of the non-aeronautical revenue generated by car parking.

Investment in airport security was considered fairly important to the Head of ICT but important to the Head of Airport Operations mainly because the benefit from these systems to operations can be negligible. For example, the security screening that was upgraded with a full body scanner, will not remove the operational bottleneck, especially during the winter season, because passengers still have to remove their coats and boots. However, according to the Head of ICT, security is a fairly important area of investment because there are benefits in other systems, such as system for identity verification combined with biometrics that would allow for faster access to certain areas without the need for staff to



perform manual verification (i.e. matching passport and boarding pass). The example cited was the system used at London Heathrow for passengers travelling on domestic flights to access airside and boarding.

The areas considered least important from an IT investment perspective are runway operations because it is an area that is under the responsibility of the Air Traffic Control. So, they do not have access to what it is invested on, and the other area is related to environmental initiatives because these areas are driven mostly by a central team. From an IT perspective, they provide the technical support needed to ensure the airport is compliant with policies and legislation (e.g. capturing data from systems to monitor energy usage, noise monitoring and other systems).

The interviewees were also asked to provide their views on the deployment of specific IT solutions to assist in four specific operations processes, and their impact on airport performance particularly aircraft turnaround. The processes and the IT solutions were: passenger processing using self-service; airport operations using airport management solutions as well as resource management solutions; airport collaboration deploying A-CDM solutions.

Self-service (i.e. self-service kiosks for passenger check-in): the use of self-service kiosks does not impact turnaround time. The self-service kiosks are not considered an airport infrastructure, although the airport provides the kiosks, the airlines can choose to use them for a cost. The KPI used is the share of passengers checking in using either counters or self-service kiosks. The airport at times considers requests from airlines who want to deploy their own dedicated kiosks but the decision to grant them the permission depends on the volume and location because in the wrong location, the kiosks can create bottlenecks as well as a becoming a liability from a safety standpoint.

Resource Management Systems (RMS) are used for the allocation of fixed resources such as gates and stands, and both interviewees considered that RMS helps the airport to reduce terminal times with proper allocation of gates, so avoiding the problem of an aircraft waiting for a parking position. The KPI is system availability. The solution is also used by the Airport Police to manage and

allocate their resources more effectively. However, despite being an automated system, the airport still does adjustments or gate changes manually.

Airport Collaborative Decision Making (A-CDM) is a platform where key stakeholders share information in real time to make fast operational decisions in a coordinated manner with minimum disruption to operations. And for Airport D, being a European airport, it follows the recommendations from Eurocontrol who is driving the implementation of A-CDM across Europe, and as result Airport D is A-CDM certified (i.e. it complies with Eurocontrol's A-CDM recommendations). According to the Head of Airport Operations the full benefit of A-CDM will materialise when all airports are compliant because the whole European airspace system will be fluent with real-time data shared amongst all airports improving predictability and aircraft turnaround.

Airport Management Systems (AMS) is the core system of airport operations whose main component is the Airport Operational Database (AODB), which was implemented in 2003 and it does have a positive impact on airport performance according to the Head of Airport Operations. The airport has a culture of sharing data in general, and to guarantee the proper use of the shared data, an agreement has been put in place to prevent the airport from selling the data. This in turn helps airlines to trust that the information they are providing is safe and being used solely for operational purposes.

The procurement process for IT projects is carefully controlled and monitored. The process at Airport D is that all IT projects fall under responsibility of IT Department but working in close collaboration with other departments. For example, if Airport Operations want to procure a new check-in solution the teams from operations and IT will work together to define the scope of work and requirements. The technical design is then defined by IT who will assist in defining potential vendors, then the Procurement Department will then release the tenders. From a budget perspective, the capital expenditure (Capex) of the project is to be raised by the department procuring the solution, and once implemented, the operational expenditure of the solution (Opex) becomes part of the IT budget.

## **Airport characteristics and its marketplace**

The interviewees were asked to describe the airport characteristics of Airport D that reflect the airport's management preferences related to (a) the use of Service Level Agreements (SLA) to measure airport performance, (b) related to the availability of resources and the use of outsourcing, and (c) about the competitiveness of the airport environment.

The interviewees strongly agree that SLA is an important element by which to measure airport performance. Airport D has an SLA of 10 minutes to process passengers, and in case of baggage processing, the agreement with ground handlers is that arrival bags the first bag must be on the belt within 20 minutes after landing. The SLA with ground handlers is not a separate agreement but it is part of the main body of contract that determines the service levels required. Therefore, it is part of the main licensing contract. Regarding the SLA for Aircraft Processing, Airport D considers it is an agreement between the airline and their ground handlers. Therefore, not relevant to Airport D. However, the airport guarantees the minimum connection time (MCT) of 40 airports (i.e. passengers transiting through the airport and connecting to another flight is guaranteed that it can be done within 40 minutes).

The answers to Airport D's preference to use outsourcing to deal with resource deployment indicate that the interviewees agree that outsourcing is used to cover the shortage of internal resources but is also used to reduce costs. The consensus between the Head of Airport Operations and Head of ICT is that skilled resources are important to achieving high performance, and both were neutral regarding the availability of skilled resources as it depends on the skills being required. For example, IT expertise in AODB is available but the challenge is salary.

The Head of ICT explained that from IT perspective there is a stronger collaboration of CIOs of major airports (i.e. Paris-Charles de Gaulle, London Heathrow, and Amsterdam Schiphol) that on a quarterly basis have information-sharing meetings so from an IT perspective, Airport D cannot consider its marketplace a competitive one. As for airports competing against each other,

there is some competition but cannot be considered intensive competition. However, this is not to say that they do not monitor what these and other European airports are doing. Airport D does not introduce new products or services as result of competition but instead the introduction is based on shared best practices and benchmarking. During the quarterly meeting airports share their best practices (i.e. what is working and not working) and equipped with this information, the airport then plans for the introduction of new products. However, the introduction of new products or services must be aligned with the airport's strategy to be a premium class provider and how IT will help the airport to achieve high service quality scores. And it is from this standpoint that the airport considers IT as being able to provide competitive advantage (i.e. to provide a better service and information to their passengers).

### **Performance measures**

The Head of Airport Operations and Head of ICT were asked to describe how the airport measures airport performance and the performance indicators. They were also asked to describe how IT performance is measured.

Airport D measures their performance based on terminal operations and financial health. The Head of ICT explained that one of the most important indicators is aircraft delay, and the airport's goal is to have on-time performance of 80% or above. Airport D has a long list of Key Performance Indicators (KPIs), and the two important KPIs are related to passenger satisfaction (ASQ) including check-in queuing time that should be less than 10 minutes, and aircraft turnaround and on-time departure (i.e. punctuality). ASQ and some of its dimensions are used as a target to be met by airport operations staff. Baggage transfer is also an important measure of the performance of the airport because the airport is the principal hub of an international carrier, which depends on ensuring no transfer bags are left behind.

And to measure IT performance, Airport D measures the number of outages, but not the duration of outages, and combines the number of outages with the severity or the classification of the systems (e.g. baggage handling system is mission-critical) to determine the performance of the system. System availability

is also an important indicator, and for mission-critical systems it must be available 99.9% of the time. However, from an operations perspective the real measure is the cost of the business caused by the outage (e.g. flight delays) instead of availability of the system.

**Summary:**

The IT culture factors that are most important are: Custodian role of IT and its responsibility for all IT matters of the airport including security and governance. However, the operational role was also considered important mainly because the operational efficiency is achieved as result of the IT. The mission critical importance of IT is high because without IT the airport cannot operate, and finally the benefits of IT to improve decision making as result of business intelligence. Airport D has a business intelligence project that is expected to deliver other benefits such as automation and data integration from other data sources that will enable the airport to have a corporate performance indicators portal allowing a more in-depth analysis of reasons for not meeting performance objectives.

The benefits of cost reductions from IT are recognised by Airport D, however, it is very important that cost reductions cannot be achieved at the expense of quality because service quality is very important to Airport D.

Airport D does not believe there is intense competition amongst airports in Europe. However, there is strong collaboration with airports sharing information, particularly from an IT perspective where CIOs meet on a regular basis. The introduction of new product or services is result of their own strategic objectives to be a premium class airport, not because of the competition. Airport D uses IT as competitive advantage because it supports the strategic objectives of being a premium class airport.

The airport characteristics that define Airport D are the preference to use SLA to measure performance; skilled resources are important to a high performing airport.

Airport performance measures are focused on terminal operations and financial health. The airport also uses ASQ scores with two key focus areas: waiting time and on-time-performance, and from an IT performance it is about availability of mission-critical systems.

Airport D considers IT to play an important role in the performance of the airport because IT enables the airport to deliver on their services, which is reflected in the adoption of technology (i.e. IT culture) at Airport D.

### **5.1.6 Discussion**

The case studies have shown that there is a relationship between IT and airport performance. In this subsection similarities and differences in IT culture (i.e. role, importance, and benefit of IT), airport characteristics, IT investment and performance measures are discussed to provide insights into the relationship between IT and airport performance.

All four airports shared the same opinion about the importance factor the IT culture, which is the mission critical function of IT because failure of an IT system can cause significant disruption, and potentially considerable reputational damage to the airport. For example, the delivery problems of an automated baggage handling system for Denver International Airport delayed the opening of the airport by almost 16 months costing the airport approximately US\$500 million (de Neufville, 1994). Therefore, the performance of an airport is highly dependent on the availability of mission critical IT systems such as baggage handling system or other systems (e.g. check-in, Flight Information Display, engineering and maintenance system).

The other factors of the IT culture (i.e. role of IT, and the benefits) showed different results. Airports A, B, and C considered operations as the most important and critical area of the airport in terms of the contribution of IT. Whilst Airport D considered the operational to be result of IT. Therefore, for Airport D the most important role was the custodian role (i.e. responsible for all technology matters). The reasons for the importance of the operational role were because IT can improve the operational efficiency of the airport through automation of operational

processes. Examples of the relationship between operational factor and performance are passenger processing with the introduction of self-service kiosks for check-in or mobile check-in allowing more passengers to be processed without additional terminal capacity. A similar result was obtained in a research by Sohn, Kim, and Lee (2012) at Incheon Airport demonstrated that airport systems such as self-service check-in, self-boarding gates, and Flight Information Display system enhanced the passenger experience and the financial performance of the airport by providing “*significant improvements in convenience, boarding time, face-to-face stress reduction, and security in general*”.

Other processes that can benefit by leveraging on technology are baggage processing through automation of baggage reconciliation reducing the number of mishandled cases and in turn reducing costs of mishandled cases, and when combined with the use of radio-frequency identification (RFID) technology could reduce by up to 25% the number of baggage mishandled cases and saving approximately US\$3bn to the industry (IATA, 2016); and real-time automated allocation of gates, stands, check-in desks and baggage carrousel to improve operations by improving on-time-performance. As can be seen from the examples, IT has a positive relationship with airport performance.

As far as the expected benefits of IT, Airports B, C and D considered improvements to decision-making through business intelligence as important benefits of IT, a similar conclusion was achieved by Zhang et al. (2011) that business intelligence will help airports and airlines to make more timely and effective decisions. For example, the ability to share information such as passenger information, aircraft information and operational information (e.g. availability of parking bays) that form the backbone of airport operations.

Airport A, however, considered cost reduction as the most important benefit of IT. For example, Miami Airport deployed electronic sensors to collect data on temperature of specific areas (e.g. baggage claim) in order to monitor and control the air-conditioning systems (i.e. more people in the claim area increase the air-conditioning, less people less air-conditioning); this enabled the airport to reduce air conditioning output thereby reducing energy costs (Bradley, 2014).

Improvements in operational efficiency and cost reductions will have an impact on the financial performance of an airport, thus establishing the relationship between IT and airport performance.

The other similarities shared by all four airports were the airport characteristics and their preference to use Service Level Agreements to measure performance. For example, in 2014 Sydney Airport agreed with airlines on a service level framework that included airport performance measurements against quality service indicators for airlines and passengers (Australian Competition & Consumer Commission, 2016). Although for Airport C in Australia this was an aspirational ambition because they don't operate formal SLAs between the airport and its various stakeholders (i.e. airlines, ground handlers, and government agencies), except for IT service level agreements between the airport and its IT suppliers.

All four airports also agreed that an important factor that contributes to the performance of an airport is skilled resources (i.e. resources with knowledge of the aviation industry), which according to Airport Cooperative Research Program – ACRP (2010) the review and availability of skilled resources should be at the top of airport management's agenda. The case studies also show that generally skilled resources are available but the challenge is to recruit them as they may be relatively more expensive as indicated by Airport A and Airport D.

The last of the airport characteristics is the competitiveness of the airport marketplace, and all airports acknowledge that there is competition, which has been described in researches of European airports (Jimenez, Claro, de Sousa, 2013; Copenhagen Economics, 2012; Forsyth, 2010), and the intensity of competition amongst international hubs in Asia (Tani and Coleman, 2013). In case of Airports A and B there is intense competition not only from airports in Asia but also from other regions. Airport C competes most domestically in Australia, and Airport D believes that there is competition but it is not as intense. Despite the competition, Airport D shares information and best practices with airports in Europe. The competitiveness of the marketplace showed a different impact on each airport. For example, for Airport A competition drives the introduction of new



products or services, and for the other three airports they are aware of what competing airports are doing. However, the introduction of new products or services is not driven by the competition. The case studies also showed that IT can also be considered to provide competitive advantage (Mata, Fuerst, and Barney, 1995; Nevo and Wade, 2010; Jaffer and Timbrell, 2014) to Airport A and Airport D but not for Airport B and C. In terms of the airport performance, all airports strive to provide a better service to their passengers, which is demonstrated by their responses to use Airport Service Quality (ASQ) scores to benchmark their performance. These four airports are part of the 318 other airports spread over 80 countries worldwide that are also using the ASQ as a customer satisfaction benchmarking tool (ACI, 2016).

Amongst all four airports in the top investment areas in IT are for solutions related to Passenger and Baggage processing because these are considered to be the core services of an airport, and investments in these areas enable greater use of self-service systems. For example, self-service kiosks and automated baggage drop where the passenger checks-in their baggage without the assistance of a check-in agent, which according to a study of a self-service implementation in Singapore by Lee, Ng, Lv and Tazoon (2014) concluded that self-service kiosks *“do indeed bring about more efficiency in the passenger processing operations”* that results in savings for airlines and an enhanced passenger experience. The investment in these areas are expected to have an impact of performance through improvements in operational efficiency (i.e. more passengers handled, reduction of mishandled cases, and monitoring of passenger journey). The investment priorities of Airports A, B, C and D is in line with industry’s trends, which according to SITA’s Airport IT Trend surveys from 2009 to 2015, showed that the investment in passenger processing has been a top investment priority for airports, while investment in baggage processing was only shown in 2015 results.

Airports C and D also highlighted the importance of Business Intelligence (BI) particularly the use of data analysis and predicative capabilities providing the airport with a single point of access to multiple applications and to enable the airport to visualise key performance indicators on one dashboard. The

importance of BI to provide real-time business intelligence and analytics improve airport operations, better management and monitoring of passenger flow management and optimisation and management of revenue are main benefits as result of investments in airport BI (SITA, 2015). The other investment areas considered important for Airport A and Airport B were the investment in security solutions such as access control and identity verification. According to Frost & Sullivan, by 2023 the total market value in airport security technology that includes access control and screening is estimated to reach US\$12.67 billion (Security News Desk, 2015) confirming that investment in airport security continues to be an important investment area.

The reasons for investing in new IT systems have to be carefully considered and cannot be at expense of quality because in an example mentioned by Airport D, the introduction of full body scanners as part of the security screening has not improved the process because passengers still have to remove their coats, boots, and other personal items before proceeding. The result of the introduction of the body scanner, the improvement in the process was negligible but it can help the airport reduce the number of manpower doing a body check. In this case, technology as a barrier because passengers are not familiar with new procedures due to the introduction of technology has also been described in a study by Giebelhausen, Robinson, Sirianni and Brady (2014) of technology as barrier or benefit to service. Therefore, the introduction of new technology may have an impact on service and must be carefully considered.

With regards to the use airport performance indicators, all four airports focused on monitoring the financial health of the airport and airport operations. The financial performance indicators mentioned were related to profitability such as gross profit margin, net profit margin and Earnings before interest, taxes, depreciation, and amortization (EBITDA). As far as the use of operational performance indicators, airports are measuring wait time or queue time at specific checkpoints such as check-in, immigration and security, and baggage collection. In addition, Service Level Agreements (SLA) are commonly used by airports to measure performance, and the ACI Airport Service Quality scores(ASQ), which relate more specifically to passenger satisfaction. All airports reported that they

do not use traditional indicators such as Work Load Unit but instead of the most common form of benchmarking is ASQ.

#### **5.1.6.1 Key Insights**

- a) There is a relationship between IT and airport performance. However, there are other factors besides IT that contribute to airport performance (e.g. new terminal infrastructure). Therefore, technology alone cannot deliver on its benefits to improve performance, training to ensure users' ability to use the system correctly, and changes in the process.
- b) Awareness of the competition is important but it should not drive the introduction of new products or services but be a strategic decision with IT supporting the introduction of the new service.
- c) Investments in IT and the expected benefits from new solutions, cannot be at the expense of quality.

In conclusion, the case studies demonstrate that there is a strong relationship between IT and airport performance, and the continued growth in the global airport IT spending, which highlights the importance of IT for airports to achieve their business objectives (SITA, 2015).

The case studies and the questionnaires used in the interviews also provided an important contribution to the design of the online survey.

## **5.2 Findings of the Survey – data analysis**

There were three categories of responses to questions related to the impact of IT culture on airport performance: closed-ended, open-ended and rating-scale. The responses to closed-ended questions were analysed in terms of the frequency of responses and presented in the descriptive statistics of this section.

For the rating-scale responses, a principal component factor analysis was carried out to calculate the factor scores. The factor scores are then applied in the subsequent correlation and regression. All statistical assumptions, as well as influential data points, were checked before running regression analyses. Finally, to answer the research questions, as well as to test the research hypotheses, both descriptive and inferential statistics were utilised by using SPSS (Statistical Package for Social Science) version 22.

### **5.2.1 Response rate**

As described in Chapter 3, Section 3.4 (Population) the total population consists of 1,608 individuals representing 445 airports in 129 countries, and 275 responses were received representing 158 airports in 75 countries, resulting in a response rate of 17.1%.

However, after a data-cleaning exercise, 15 airports were removed from the list due to incomplete or blank responses. This resulted in a final sample size consisting of 260 responses representing 154 airports in 70 countries, leading to a revised lower response rate of 16.3%.

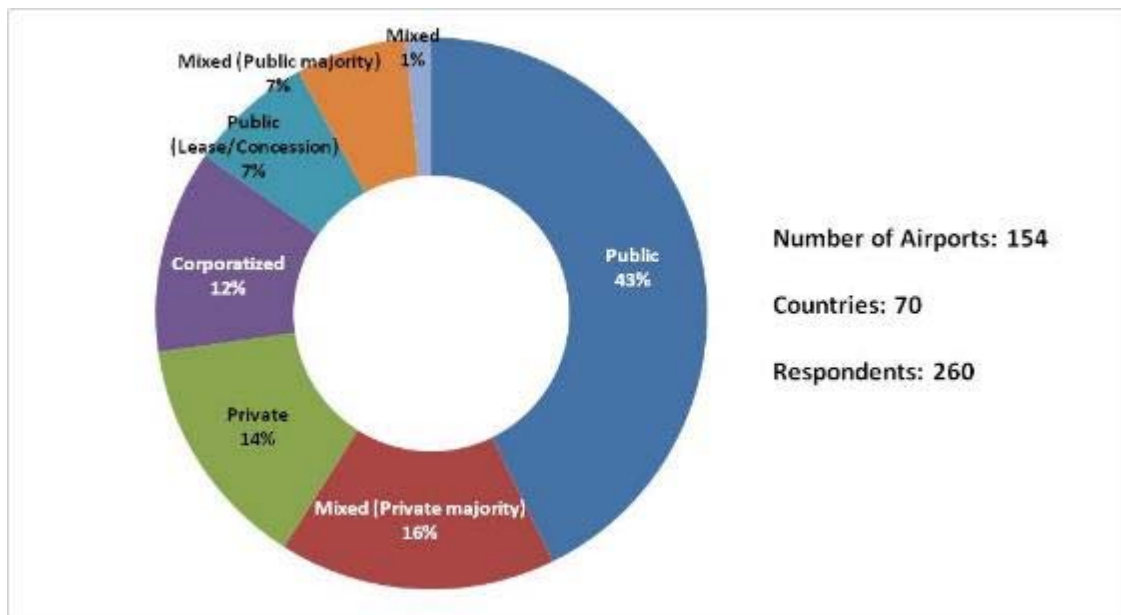
Typically, response rates for airport surveys will range from 32% (Francis et al., 2002) to 40% (Halpern, 2006). For online surveys, response rates range from 20% to 47% (Nulty, 2008).

Although the response rate of this survey appears to be slightly low, given the fact that multiple respondents from the same organisation at a number of airports participated in the survey, the results obtained are considered to be relatively robust.

Moreover, Morton et al. (2012) indicate that “several recent studies demonstrated that there is no direct correlation between response rate and validity. Visser et al. (1996) argue that some studies with low response rates, even as low as 20%, are able to yield more accurate results than studies with response rates of 60% to 70%.” Still, caution is recommended when interpreting data from surveys with lower response rates, regardless of what is agreed as an acceptable response rate, according to the Airport Cooperative Research Program (ACRP) Guidebook for Conducting Airport User Surveys.

### 5.2.2 Descriptive statistics

The 260 respondents represented 70 different countries with 42.7% of airports located in Europe, 25.4% located in Asia Pacific, 15.8% in North America (i.e. USA and Canada), 12.3% in the Middle-East, and 3.8% in the Latin America and Caribbean region. The ownership distribution is presented in Figure 39 below.



**Figure 39. Distribution of the ownership structures.**

The largest number of respondents were based in the USA (26 respondents, 37.14%), followed by India (18 respondents, 25.71%) and UK (16 respondents, 22.85%).

The respondents represent different functional roles, 28.6% is represented in Information Technology, 25.9% of them are in operations, 10.6% of them are in

finance and administration, 4.7% of them are in commercial, 4.7% of them are in engineering and 3.1% of them are in legal affairs. Amongst the respondents, 7% are in senior executive roles, ranging from CEOs to Managing Directors and General Managers.

From an organisational perspective (i.e. reporting line of CIO) the majority (61.4%) of Chief Information Officers (CIOs) report directly to the Chief Executive Officer (CEO), an indication that IT is an executive role that is focused on the firm's strategy and process (Chun and Mooney, 2009). The majority of respondents (85%) consider operational performance as the most important factor to ensure airport competitiveness. In terms of resources, 96.4% of respondents agree that skilled technical and operational resources are an important element of a high-performing airport; and 42% view outsourcing as a way to improve airport performance. However, 40.4% of the respondents are ambivalent about outsourcing.

The responses related to IT culture (i.e. role, importance, and benefits of IT) show that the respondents' priority is to improve the operational efficiency of the airport, the mission-critical function of IT is considered the most important function of IT, 95% of the respondents indicate that IT has a positive contribution to the performance of the airport, and the most important benefit of IT is in enabling the airport to do things differently and to become more competitive.

Airports have at their disposal different ways in which to measure performance, and the results show the top three measures: operational indicators (e.g. queuing time and operational SLA), financial indicators (e.g. Return on Investment, Return on Invested Capital, EBITDA and other financial metrics) and the ACI ASQ. The use of traditional performance indicators (e.g. WLU) was the fourth option in terms of importance as a performance measure, followed by airport benchmarking methodologies (e.g. DEA), Skytrax Airport Ranking and ATRS Global Airport Benchmarking.

The results show that 65% of the airports participate in the ACI ASQ surveys and 87% of them use the ASQ service dimensions to improve airport performance. The service dimensions, ranked in order of importance, are: overall passenger

satisfaction, security, airport facilities, check-in, airport way finding, airport environment, access, and arrival.

The survey also asked respondents to indicate their opinion on the importance of selected systems to the performance of their airport. Based on the weighted average, the systems are listed in order of importance from highest to lowest: Flight Information Display System, which provides information about flight status and location of check-in and gates; shared infrastructure for check-in, such as counters (CUTE) and kiosks (CUSS); Airport Operational Database (AOBD), which provides the integration of systems and ensures that data / information is exchanged in real time. In some instances, airports will use the FIDS database as their AOBD; Automated Baggage Handling and Reconciliation System, a mission-critical system for any airport; Resource Management System (RMS) used to provide automated allocation of resources such as gates and parking stands; and Airport Collaborative Decision Making (A-CDM), a new concept that is widely accepted in Europe, because of Eurocontrol, and by FAA in the USA.

In terms of IT investment, 97.5% of the respondents consider IT important for airports to improve performance, and the respondents identified the following areas of investment on IT that will help the performance of their airport: airport operations, passenger and baggage processing services, and commercial areas (e.g. point of sales and car parking).

The results of the survey show that 65.5% of the respondents consider SLA to be an important tool with which to measure airport performance. SLAs are mostly used to manage baggage processing time and passenger processing time.

### **5.2.3 Inferential statistics**

In this subsection, the factor scores for IT culture and the reliability of the rating-scale items (Q-5, Q-6, and Q-7) are first discussed, followed by the hypotheses tests.

#### **5.2.3.1 Factor scores of the IT culture factors.**

There are two approaches to factor score analysis: refined and non-refined. Refined methods create factor scores using more sophisticated approaches than

non-refined methods (DiStefano, Zhu & Mindrila, 2009). They are more accurate than non-refined methods and provide estimates that are standardised scores equalling to Z scores (+ or - 3).

There are three methods for refined computation; namely, Regression score, Bartlett score and Anderson-Rubin score. Amongst these, the main advantage of the regression score method is that it maximises validity, which utilises a least squares regression approach to predict factor scores. In this study, regression scores (of factors) were used for the subsequent analyses.

Three factors: Role of IT, Importance of IT and Benefit of IT, which incorporate a total of 14 statements in Questions 5 to 7, were scored as follows: Not at all important = 1, Slightly important = 2, Important = 3, Fairly important = 4 and Very important = 5. Whereas the score 5 indicates the on-direction to the factors and the score 1 indicates the off-direction to the factors.

To check the reliability of the factors, Chronbach's Alpha (reliability measure under internal consistency or a single dimension) was calculated and found an acceptable reliability rate of .83 for the Importance of IT factor, and no reliability rate was determined for the Role of IT and Benefit of IT factors because of a negative covariance among items. Table 11 represents the factors, along with their factor loadings and reliabilities. Factor-loading scores are the regression / correlation coefficients between the measured variables and the corresponding factor score (factor score is a linear combination of the measured variables that load on the factor of interest). In principal component analysis, the component matrix (the table below) contains partial standardised regression coefficients as factor-loading scores. For example, there are four measured variables or indicator variables for the factor "Role of IT". Holding other measured variables constant, the partial regression coefficient of the variable Q5.1 is -.823. In other words,  $(-.823 \times -.823) = .68$  or 68% of Q5.1 variable's variance is shared with the factor "Role of IT".



Factor-1: Role of IT			
Item #	Statements	Factor Loadings	Cronbach's Alpha
Q5.1	Strategic role plays an active role in defining the airport's strategic goals.	-.823	Not determined
Q5.2	Operational role plays an important role to improve operational efficiency of the airport.	.188	
Q5.3	ICT <sup>28</sup> Custodian is responsible for all IT-related matters of the airport.	.886	
Q5.4	Transformational role plays an important role to change the airport processes through deployment of technology.	-.248	
Factor-2: Importance of IT			
Item #	Statements	Factor Loadings	Cronbach's Alpha
Q6.1.	ICT plays a mission-critical role.	.700	.835
Q6.2.	ICT is key to the airport's growth.	.690	
Q6.3.	ICT is deployed to enhance the airport's products and services.	.833	
Q6.4.	ICT addresses the airport's needs for automation and technology.	.819	
Q6.5.	ICT has a positive contribution to the performance of the airport.	.867	
Factor-3: Benefits of IT			
Item #	Statements	Factor Loadings	Cronbach's Alpha
Q7.1.	ICT enables the airport to do things differently and to become more competitive.	.468	Not determined
Q7.2.	ICT helps to reduce costs.	.630	
Q7.3.	ICT is deployed to differentiate the airport's products and services.	.356	
Q7.4.	ICT brings innovation and encourages innovation.	-.646	
Q7.5.	ICT such as Business Intelligence technologies improve decision-making and long-term planning.	-.678	

**Table 11. Factor loadings of items in Q-5, 6, 7 and their reliability rates.**

<sup>28</sup> The term ICT (Information and Communications Technology) and IT (Information Technology) have been used with the same meaning.

### 5.2.4 Hypotheses testing

This study comprises six main hypotheses based on the impact of IT culture on airport performance. The test results of these hypotheses are as follows, under separate headings:

***H1: There is a relationship between IT culture and airport performance.***

As described in Subsection 4.8.3, principal components analysis was applied to determine the factor scores for IT culture (i.e. role, importance and benefits of IT). To test this hypothesis, a correlation analysis between two continuous variables (i.e. the three IT culture factors and airport performance) was carried out, as well as a multiple regression analysis with two control variables: ownership structure of the airports, and airport size. The following table (Table 12) presents the correlation between the IT culture factors and airport performance.

IT culture Factors	Airport Performance	p Values
Role of IT	.113	.111
Importance of IT	.062	.384
Benefit of IT	-.086	.224

**Table 12. Correlation between IT culture factors and airport performance.**

As can be seen from the above table, the relationship between the IT culture factors and airport performance are very weak and none of the correlation coefficients are statistically significant ( $p > .05$ ).

Before running multiple regression, the statistical assumptions for homoscedasticity, linearity and normality were met. A Durbin-Watson value of 1.40 indicates that the assumption of independence was also met. Furthermore, there were no tolerance values less than 0.2 and no VIF values greater than 10, which indicates that there were no influential data points.

In this multiple regression model, the criterion variable is airport performance and the predictor variables are the three IT culture factors, along with two control

variables (ownership structure and airport size). The control variable- ownership was removed from the model as it turned out to be an insignificant contributor.

However, in the refined model (IT culture factors and airport size), the full model was statistically significant ( $F_{4, 196} = 8.88, p < .05, R^2 = .156$ ), and 15.6% variance in airport performance was explained by the full regression model (three IT culture factors, along with the control variable- airport size). The regression estimation results are presented in Table 13.

Amongst the three IT culture factors, only the benefit of IT factor, which is negative, was statistically significant ( $\beta = -.138, t = -2.048, p < .05$ ). Furthermore, the control variable- airport size was statistically significant ( $t = 5.310, p < .001$ ). Therefore, it can be concluded that, after controlling airport size, only the benefit of the IT factor has a negative impact on airport performance.

Airport Performance					
	Coef.	Std.	Stand. Coef.	t values	p Values
Role of IT	222.979	124.728	0.123	1.788	0.075
Importance of IT	-0.390	129.901	0.000	-0.003	0.998
Benefit of IT	-250.474	122.298	-0.138	-2.048	0.042
PAX	0.0000274	0.000	0.364	5.310	0.000
<i>Observations</i>	196				
<i>F-statistic</i>	0.000				
<i>R-squared</i>	0.156				

**Table 13. Airport Performance estimation based on IT culture factors regression results.**

The statistical results are rather counter-intuitive, because the general expectation is that the expected IT benefits would have a positive impact on airport performance. However, there is one variable that would move in the opposite direction and that is cost reduction, because as costs go down performance goes up. Brynjolfsson and Hitt (2000) argue that the value of IT is derived from the ability to enable “complementary organisational investments” (i.e. processes and practices), which in turn increases productivity by reducing costs.

Comparing the results from the interviews and the statistical results, for Airport A in Southeast Asia, cost reductions is the most important benefit of IT, which leads to operational improvements due to automation of process.

***H2a: There is a relationship between management – SLA and IT culture.***

To test this hypothesis, correlation analysis between the three IT culture factors and Management-SLA was carried out. The following table (Table 14) presents the correlation coefficients.

IT culture Factors	Management-SLA	p Values
Role of IT	-.109	.142
Importance of IT	.228*	.002
Benefit of IT	-.101	.177

Note. \* indicates statistically significant at .001 alpha level

**Table 14. Correlation between IT culture factors and management (SLA).**

The above correlation coefficient table shows that only the importance of IT culture factor as statistically significant. However, a weak positive correlation with Management-SLA ( $r = .228$ ,  $p < .05$ ,  $r^2 = .052$ ), and around 5.2% variance in the importance of the IT culture factor was explained by Management-SLA. Therefore, it can be stated that the importance of IT is positively correlated with management preferences (SLA).

The importance of IT refers to areas that are important for airports; for example, IT plays a mission-critical role. The mission-critical role of IT is, as explained by the interviewed airports, because if IT fails the airport operations and processes break down. The mission-critical importance is very much an operational area, and SLA (Service Level Agreements) are the contractual guarantees between the airport and IT vendor on the reliability and availability of the system, which would explain the relationship between the IT culture factor and the management preference to use SLA.

**H2b: There is a relationship between ownership structure and IT culture:**

To determine the association between ownership structure and IT culture factors, three linear regression models with categorical predictors for three IT factors were tested. Most of the airports in the sample were classified as publicly-owned. Therefore, all other types (six categories) were compared to publicly-owned airports as a reference category; and  $k-1$ , where  $k$  is the total number of categories, i.e.,  $7-1 = 6$  dummy variables were created before running the regression models.

As the IT culture has three factors; namely, 1) role of IT, 2) importance of IT and 3) benefits of IT, three different regression models were tested where the 6 dummy variables were entered in the models as predictor variables, and the priority of IT was a criterion variable in the first model, the importance of IT was a criterion variable in the second mode, and the benefits of IT was in the third model as a criterion variable.

Models	$R^2$	$F$	$df$	$p$
First	.024	.817	6, 196	> .05
Second	.042	1.43	6, 193	> .05
Third	.007	.25	6, 196	> .05

**Table 15. Summary of the ownership structures regression model.**

The test results showed in Table 15 indicates that the predictor variables (6 dummy variables) explained only 2.4% variance in the role of IT factor, 4.2% variance in the importance of IT factor and 0.7% variance in the benefit of IT factor. All three models were found not to be significant regression models ( $p > .05$ ). Consequently, it can be inferred that the type of ownership structure has no significant association with IT culture.

With a view to triangulate the regression model results, a one way MANOVA was run to determine if the IT culture factors are significantly different based on the ownership structure. The differences between the IT factors based on ownership structure were not statistically significant ( $p > 0.05$ ), which corroborates the results from the multiple regressions.

***H2c: There is a relationship between outsourcing and IT culture.***

To test this hypothesis, correlation analysis between the three IT culture factors and outsourcing index was carried out. The following table presents the correlation coefficients.

IT culture Factors	Outsourcing	p Values
Role of IT	-.140	.050
Importance of IT	.120	.096
Benefit of IT	-.177	.105

Note. \* indicates statistically significant at .05 alpha level

**Table 16. Correlation between IT culture factors and outsourcing.**

As per Table 16, no significant relationship was found between IT culture factors and outsourcing, which means there is no relationship between outsourcing and IT culture factors. It could be assumed that in the case of an IT Outsourcing, such as the case of Dusseldorf Airport, it is expected that the role and importance of IT would be downplayed, because they are driven by contractual obligations related to performance and service delivery.

***H2d: There is a relationship between competition intensity and IT culture.***

To test this hypothesis, Spearman's rho correlation analysis between the three IT culture factors and competition intensity was carried out. The following table presents the correlation coefficients between the IT culture factors and competition intensity.

IT culture Factors	Competition Intensity	p Values
Role of IT	.012	.868
Importance of IT	.144	.044
Benefit of IT	-.052	.473

Note. \* indicates statistically significant at .05 alpha level

**Table 17. Correlation between IT culture factors and competition intensity.**

As per Table 17, the correlation coefficient table indicates that the importance of the IT factor has a weak positive relationship with Competition Intensity ( $\rho = .144$ ,  $N = 195$ ,  $p < .05$ ). The result validates the response from Airport A. which indicated that IT is used to provide airports with competitive advantage, which in the case of Airport A spurred them to develop and introduce new products and services.

***H3: There is a relationship between airport characteristics and airport performance.***

This hypothesis was tested by a multiple regression model where airport performance was the dependent variable; and competition intensity, operational resource as well as outsourcing (Q-3 index), Service Levels Agreements (Q-15 index) were the predictor variables, along with ownership structure and airport size as control variables. Prior to running the multiple regression analysis, all the statistical assumptions were checked, and all the assumptions; namely, the assumptions of homoscedasticity, linearity and normality were met.

The Durbin-Watson value of 1.518 indicates that the assumption of independence was also met. Furthermore, there were no tolerance values less than 0.2, and no VIF values greater than 10, which indicates that there were no influential data points. After running this initial regression model, the control variable- ownership structure was eliminated as an insignificant contributor, which is why it was removed from the initial regression model. The refined model then came out as a significant full regression model ( $F_{4, 186} = 11.021$ ,  $p > .001$ ,  $R^2 = .192$ ), where 19.2% variance in airport performance was explained by the full regression model.

From the three predictor variables, Service Level Agreements (Q-15 index) was found to be a significant predictor ( $\beta = 2.67$ ,  $t = 3.820$ ,  $p < .001$ ), and the control variable- airport size was found to be significant as well ( $\beta = .308$ ,  $t = 4.520$ ,  $p < .001$ ). Therefore, it can be concluded that after controlling for airport size, airport characteristics, namely Service Level Agreements, are associated with airport performance. The results are presented in Table 18.

Airport Performance					
	Coef.	Std.	Stand. Coef.	t values	p Values
Competition Intensity	-27.079	124.203	-.015	-.218	.828
Outsourcing	-139.944	77.267	-.123	-1.811	.072
Service Level Agreements	131.871	34.525	.267	3.820	.000
PAX	0.00002302	.000	.308	4.520	.000
Observations	190				
F-statistic	0				
R-squared	0.192				

**Table 18. Airport Performance estimation based on airport characteristics regression results.**

This result validates the responses from the face-to-face interviews who indicated that they consider SLA to be an important tool with which to measure airport performance.

***H4a: There is a relationship between ASQ dimensions and airport performance.***

To test this hypothesis, correlation analysis between ASQ dimensions and airport performance was utilised. The following table (Table 19) presents the correlation coefficients between the ASQ dimensions and airport performance.

ASQ Dimensions	Airport Performance	p Values
Overall passenger satisfaction	.233*	.010
Check-in	-.155	.089
Security	-.140	.124
Finding way through the airport	-.176	.053
Airport facilities	.170	.062
Access	-.006	.925
Arrival	-.168	.064
Airport environment	.227*	.012

Note. \* indicates statistically significant at .05 alpha level

**Table 19. Correlation between ASQ Dimensions and airport performance.**



The above correlation coefficient table shows that both overall passenger satisfaction ( $r = .233$ ,  $p < .05$ ,  $r^2 = .054$ ) and airport environment are associated with airport ( $r = .227$ ,  $p < .05$ ,  $r^2 = .051$ ) performance. This result validates the view that satisfied passengers spend more at the airport (JD Powers, 2008), therefore positively contributing to financial airport performance.

***H4b: There is a difference in airport performance based on use of ASQ.***

Two-sample independent t-tests were carried out to look at the difference between the airport that uses ACI ASQ services and the airport that does not use ACI ASQ services based on passenger satisfaction and airport environment

The results indicate that there was no significant difference between the airports that use ACI ASQ service and those that do not on overall passenger satisfaction ( $t = .288$ ,  $df = 116$ ,  $p > .05$ ), and airport environment ( $t = -.890$ ,  $df = 116$ ,  $p > .05$ ).

***H5: There is a relationship between IT investment and airport performance.***

To test this hypothesis, first a correlation analysis between airport performance and IT investment was performed, followed by a multiple regression analysis. In the correlation analysis, the correlation coefficient between IT investment and airport performance indicated that there was no significant relationship ( $r = .08$ ,  $p > .05$ ,  $r^2 = .006$ ) between airport performance and IT investment. In multiple regression analysis, the dependent variable was airport performance, whereas the predictor variable was IT investment with the control variables- ownership structure and airport size.

The control variable- ownership was removed from the initial regression model, as it was found not to be a significant contributor in the model. After checking all the relevant assumptions as sound, the refined regression model was observed to be a significant regression model ( $F_{2, 195} = 10.031$ ,  $p > .001$ ,  $R^2 = .093$ ) where 9.3% variance in airport performance was explained by the refined model. This result indicates that there are other variables that have not been accounted for in the model, which could also prove to be statistically significant determinants. For

example, IT governance to ensure the investment is aligned with the airport's strategic objectives, and to determine where to spend (e.g. investment in IT capabilities or IT resources, investments in R&D and hardware).

The predictor variable- IT investment was observed not to be a significant indicator ( $\beta = .049$ ,  $t = .710$   $p < .05$ ) of airport performance, after controlling for airport size. Therefore, it can be concluded that IT investment was not associated with airport performance. The results are presented in Table 20.

Airport Performance					
	Coef.	Std.	Stand. Coef.	t values	p Values
IT Investment	23.384	32.952	.049	.710	.479
PAX	2.062E-05	.000	.296	4.317	.000
Observations	197				
F-statistic	0				
R-squared	0.093				

**Table 20. Airport Performance estimation based on IT investments regression results.**

This important finding from the data is supported by Zehir et al. (2010), who also found no strong relationship between IT investments and firm performance.

***H6: There is a relationship between selected IT systems and airport performance.***

To test this hypothesis, correlation analysis between the six IT systems and airport performance was carried out. The following table presents the correlation coefficients between IT systems and airport performance.

	Airport Performance	p Values
CUTE & CUSS	.200*	.004
RMS	.151	.031
AODB	.268**	.000
FIDS	.180*	.010
BAG	.318**	.000
A-CDM	.267**	.000

Note. \* indicates statistically significant at .05 alpha level

\*\* indicates statistically significant at .001 alpha level

**Table 21. Correlation between IT systems and airport performance.**

Table 21 presents the correlation coefficients between IT systems and airport performance, where all of the selected systems were found to have a significant relationship with airport performance. Among the selected IT systems, AODB, BAG and A-CDM were significant at 1% alpha level, whereas CUTE & CUSS, RMS, and FIDS were significant at 5% level of significance. All the correlation coefficients were positive, indicating a direct relationship between the two variables studied. Thus, if the respondent agreed that a particular system the airport performance value would be higher than if that particular respondent disagreed with the statement. Therefore, it can be said that IT systems have a relationship with airport performance.

### 5.3 Chapter summary

In Chapter 5, the detailed analysis of the results was presented in two sections: case studies as result of the face-to-face interviews, and the results of the online survey.

Section 5.1 presented the case studies of four airports one in Southeast Asia, one in Northeast Asia, one in Australia, and one in Europe, which showed that from the interviewees' perspective there is a positive relationship between IT and airport performance. As result of the case studies and input provided by the interviewees, the questionnaire used in the online survey was modified.

Section 5.2 and 5.3 presents the results of the online survey and the hypothesis testing. The table 22 shows the results of the hypothesis testing:

Hypothesis	Relationships	Direction	Outcome
H1	There is a relationship between IT culture and airport performance	Same	Opposite
H2a	There is a relationship between management – SLA and IT culture	Same	Same
H2b1	There is a relationship between ownership structure and IT culture	Same	No relationship
H2b2	There is a difference in IT culture based on ownership structure	N/A	N/A

Hypothesis	Relationships	Direction	Outcome
H2c	There is a relationship between outsourcing and IT culture	Same	No relationship
H2d	There is a relationship between competition intensity and IT culture	Same	Same
H3	There is a relationship between airport characteristics and airport performance	Same	Same
H4a	There is a relationship between ASQ dimensions and airport performance	Same	Same
H4b	There is a difference in airport performance based on the use of ASQ	N/A	N/A
H5	There is a relationship between IT investment and airport performance	Same	No relationship
H6	There is a relationship between selected IT systems and airport performance	Same	Same

**Table 22. Summary of results from the hypotheses testing.**

### **5.3.1 Major findings**

This subsection provides an overview of major findings from the Airport Case Studies and Online Surveys. Additional discussions on the findings and conclusion can be found in Chapter 6.

**IT culture and airport performance.** An opinion that was shared by all interviewees represented in the four Airport Case Studies is that IT has a positive contribution to airport performance, and the key IT culture factors that are relevant to them were:

Role of IT: the operational role was considered the most important because of its role to improve operational efficiency of the airport, and the least important role was the strategic role because as explained by Airport C in Australia IT is an enabler of business (i.e. it supports the organisation to deliver on the airport's strategy).

Importance of IT: the mission-critical function of IT was considered the most important function for all interviewees because without IT the airport cannot function (e.g. building management systems that control heating and air-conditioning, systems that control other systems (e.g. escalators, lifts, and automated doors), baggage handling systems and check-in systems. The least important function, was IT a key contributor to the growth of the airport because growth is function of demand and IT has no influence on demand.

Benefits of IT: cost reduction was an important benefit for Airport A in Southeast Asia, whilst to improve decision making through business intelligence was important for Airport B in Northeast Asia and Airport C in Australia, and for Airport D in Europe. And the least important benefit is innovation, which as explained by Airport D, airports are not innovative in nature, they are fast-followers, which means airports will deploy a solution only after seeing it successfully implemented at another airport.

However, the results hypothesis testing of the relationship between IT culture and Airport performance show that amongst the three IT culture factors only the benefit of IT, which is negative, was statistically significant.

**Management Preference and IT culture.** The Case Studies show that airport characteristic of management preference to use Service Levels Agreements was an important tool to measure airport performance for all airports although it was considered as an ambition for Airport C in Australia. The statistical analysis shows that importance of IT (i.e. mission critical function of IT) is positively correlated with management preferences, which can be explained because of the criticality of a system, the airport will put in place a stringent SLA with maximum system availability.

**Airport Service Quality (ASQ) and airport performance.** The airports represented in the case studies agree that ASQ is used by their airports to measure performance, and the online survey results show that 65% of the airports participate in the ACI ASQ surveys and 87% of them use the ASQ service dimensions to improve airport performance. And the statistical analysis show that

the ASQ dimensions of overall passenger experience and the environment are associated with airport performance. However, there was no significant difference between airports that use ASQ and airports that don't use ASQ.

**IT Investment and airport performance.** The Case Studies show that investments in airport systems are done to improve operational areas such as passenger and baggage processing (e.g. additional self-service kiosks, automated bag drops, new baggage handling systems), airport operations that includes Airport Collaborative Decision Making (A-CDM) and business intelligence. The statistical analysis shows that six of selected systems (i.e. Common Use – CUTE and Self Service; Resource Management System - RMS, Airport Operational Database - AODB, Flight Information Display System – FIDS, Baggage System, and A-CDM) have a relationship with airport performance.

However, the statistical analysis also shows that IT investment was not associated with airport performance. According to the CIO of Airport B in Northeast Asia, he believes that IT spend information should be used with caution because it can give misleading results. For example, high investment does not necessarily mean the spend has been effective. Therefore, to establish the relationship between IT investment and airport performance purely on monetary terms is incomplete. Other factors such as governance would have an impact on how the money is spent and factors such as training, and end-users' ability to use the system correctly would also have an impact on performance.

**Airport Performance Indicators.** The Case Studies shows that the airports are using the financial indicators (e.g. gross profit margin, net profit margin, and EBITDA) and operational indicators such as wait-time at key touchpoints (i.e. check-in, security and immigration), Service Level Agreements and Airport Service Quality (ASQ) scores. The results of the online survey also show similar responses with the top three measures being: (1) operational indicators including Service Level Agreements; (2) financial indicators; and (3) ASQ.

## 6 CONCLUSIONS AND RECOMMENDATIONS

The main objectives of this chapter are threefold (1) to summarise the main findings and conclusions, (2) the implications of the findings, and (3) recommendations for future research.

### 6.1 Summary of the findings and conclusions

The summary of the findings is presented in relation to the aim and objectives of this research, as set out in Chapter 1, Section 1.3.

**Aim:** *To assess the relationship between IT and airport performance*

Nine hypotheses have been tested to demonstrate the achievement of the objectives of this research, and their results are described below.

**Objective 1:** To determine IT culture and its relationship to airport performance through understanding of the role, importance and benefits of IT.

H1. There is a relationship between IT culture and airport performance

The IT culture factor is made up by three elements: the role of the IT, the importance of IT and the benefits of IT. The test results show that the only statistically significant relationship is between benefits of IT and airport performance and that it is inversely associated with airport performance. Thus, when the airport performance value goes up, the benefits of IT factor value goes down. It should be noted that the association is weak.

One of the benefits of IT is to help airports reduce costs; for example, using SITA's ROI Calculator, an airport using an automated Baggage Reconciliation System and handling 100,000 bags a year with a 2% mishandled situation would reduce their costs by US\$24,800, which would have an association with an airport's financial performance.

The Case Studies also confirmed that different factors of the IT culture have a positive relationship with Airport Performance, which for Airport A the most important benefit of IT for their airport was the reduction of cost

as results of automation, which helps the performance of the airport. An example cited by Airport B is that the airport was able to expand its terminal capacity by 55% through the technology (e.g. self-service) that resulted in delaying the cost of terminal expansion.

The results of the hypotheses tests demonstrated the achievement of this objective.

**Objective 2:** To determine the airport IT characteristics that have an association with airport IT culture

Four hypotheses have been created to determine the association between an airport's IT culture and its' characteristics. An additional hypothesis was created to determine if there were any differences in IT culture factors based on the ownership structure of an airport.

H2a. There is a relationship between management – SLA and IT culture

The test results show that the importance of IT has a positive and weak correlation with management preferences (SLA). Thus, when the value for the SLA index goes up, so does the value for the importance of IT factor.

The survey results also show that 65.88% of the respondents consider SLA to be an important tool with which to measure airport performance. This was also an opinion shared by three of the case study airports (Airport A, Airport B, and Airport D). However, for Airport C in Australia, these are aspirational ambitions.

H2b1. There is a relationship between ownership structure and IT culture

H2b2. There is a difference in IT culture based on different ownership structures

The test results show that there is no statistically significant relationship between the different types of the ownership structure and IT /culture. In addition, there are no statistically significant differences in the IT culture factors based on different ownership structures. This result contradicts some findings in other industries such as Basant et al. (2006) in their study



on the adoption of IT and productivity of manufacturing companies in Brazil and India, suggest that ownership structure is strongly related to use and adoption of IT, and Choi, Park and Hong (2012) study of Korean firms where they found that some ownership structures (e.g. institutional) have a positive effect on innovation. They also suggest that for greater effectiveness a closer alignment between ownership structures and governance should be strived for.

#### H2c. There is a relationship between outsourcing and IT culture

The test results show no statistically significant relationships; therefore, outsourcing is not associated with IT culture. Further studies will be required, as the expectation is to have an association due to of the nature of outsourcing as a strategic tool (Verma, 2000). The Case Studies showed that an important element that contribute to airport performance is skilled resources, and that airports use outsourcing to cover gaps in the availability of resources or specific tasks (e.g. IT maintenance, trolley management). However, IT is not considered a critical skill, and very few airports (e.g. Dusseldorf, London Heathrow, and Delhi) have embarked on a full IT outsourcing.

#### H2d. There is a relationship between competition intensity and IT culture

The test results show that the importance of IT has a weak positive relationship with Competition intensity. The importance of IT reflects operational items such as mission-critical roles, technology to enhance products and services, to address the automation needs of an airport, and these can be driven by intense competition. The Case Studies showed as result of competition airport such as Airport A, which is continuously improving and enhancing their products and services that in turn gives them a competitive advantage. A similar response was given by Airport B, and Airport D. However, for Airport C in Australia did not have a strong opinion about the airport brining new products or services due to the competition.

The results of the hypotheses tests demonstrated the achievement of this objective.

**Objective 3:** To determine if airport IT characteristics have an association with airport performance.

H3. There is a relationship between airport characteristics and airport performance

The conceptual framework, as described in Section 2.6 describes the internal and external characteristics that would have an association with airport performance, which are based on internal capabilities (i.e. management preferences (SLA), resources (outsourcing), ownership, and external influences (i.e. competitive environment).

The test results show that Service Level Agreements are a statistically significant predictor for airport performance. The results also reflect the responses from the airport staff interviewed who use SLA as a tool to measure airport performance, because SLA are measured against very specific indicators, such as availability of 99.5%. The Case Studies also showed that SLA are an important tool to measure airport performance, and as explained by Airport C in Australia, IT systems are procured to address specific issues such as congestion, and as result the airport will be able to measure its performance and the SLA for the system will assist in monitoring the congestions (e.g. queue build-up) and take corrective actions. Airport C in Northeast Asia uses SLA for continue improvement of operations.

The tests demonstrated that airport characteristics (i.e. management preferences – SLA) are associated with airport performance. Therefore, the result of the test demonstrated the achievement of this objective.

**Objective 4:** To determine the relationship between IT investment and airport performance.

The hypothesis was created to determine the relationship between investments in IT to improve airport performance:

H5. There is a relationship between IT investment and airport performance

The test results show that there is no relationship between IT investment and airport performance. The relationship between IT investment and business performance has been a widely researched subject investigated with mixed results, with some studies showing positive and significant relationships and other studies showing no significant relationship between investments in IT and performance (Sheng and Mykytyn Jr, 2002). The survey results show that 85.05% of the respondents' opinion is that investment in IT to improve airport performance is fairly to very important. The Case Studies showed that all four airports are investing in areas such as Passenger and Baggage Processing because they are key to deliver on their strategy to enhance the passenger experience (i.e. invest to support their business). And all interviewees agree that IT has a positive contribution to airport performance but not necessarily IT investment.

The results of the hypothesis test demonstrated the achievement of this objective.

**Objective 5:** To determine from selected IT Systems the ones that have an association with airport performance.

The hypothesis was created to determine the relationship of selected IT systems and airport performance:

H6. There is a relationship between selected IT and airport performance

The test results show that all systems (i.e. CUTE & CUSS, AODB, RMS, FIDS, BAG, A-CDM) show a significant relationship with airport performance. The correlation coefficients are positive and indicate a weak relationship, except for BAG, where the correlation coefficient is positive and indicates a moderate strength for the relationship. Thus, when respondents agree with, that the value for the airport performance

increases versus when respondents disagree with the statement. The Case Studies also showed that these systems (i.e. CUTE & CUSS, AODB, RMS, FIDS, BAG, A-CDM) can contribute to airport performance. However, the CIO of Airport C considered that AODB was simply a data repository. Therefore, not expected to improve performance. Another system, that was considered to contribute on the performance of the airport was Business Intelligence.

The hypothesis related to the use of Airport Service Quality dimensions was included in the research as result of the feedback received from airports that participated in the case study. Therefore, the hypotheses below were created to determine which dimensions of the Airport Service Quality have an association with airport performance.

H4a. There is a relationship between ASQ dimensions and airport performance

H4b. There is a difference in airport performance based on the use of ASQ

The survey results show that the number of respondents that participate in the ACI ASQ survey are 139 (64.73%) of the total respondents, and the three most important performance measures are operational indicators such as queuing time (4.27), financial indicators (4.26) and ACI ASQ (4.04).

The first hypothesis test results show that out of the eight areas of the ASQ, overall passenger experience and the airport environment (i.e. ambience and cleanliness of the terminal) are statistically significant correlated with airport performance. The correlation coefficient for both ASQ areas was positive and it showed a weak relationship, indicating that as values for overall passenger satisfaction or values for airport environment increase, so do the values for airport performance. The second hypothesis test results for the two dimensions (overall passenger satisfaction, airport environment) show that there is no statistically significant difference between airports that use the ASQ survey and those that don't. The Case Studies showed that all four airports use ASQ to

measure their performance related to passenger satisfaction, and use the ASQ as a benchmark tool of their performance.

The results of the tests demonstrated the achievement to determine the relationship between ASQ dimensions and airport performance.

## **6.2 Implications of the findings**

### **6.2.1 IT culture**

Information Technology in the context of airports is still primarily an operational role to drive airport efficiency. This can be reflected in the fact that it has a mission-critical role; that is, if a major IT system fails, the whole airport grinds to a halt. A system, such as the baggage handling system, is in the background and is not visible to passengers, but an outage can create major operational disruption depending on the length of time the outage lasts.

Low in the priorities is the transformational role (i.e. changing processes through the deployment of technology). This may be reflected in the fact that airports are fairly conservative when it comes to adopting new technology; the user of this approach was described by one airport as being a “fast follower”, someone who will see what happens to others before joining in. However, technology is rapidly changing, and passengers are and will be demanding more from airports. Therefore, there may be little advantage in airports adopting a reactive “wait and see” approach.

The transformational role of IT is the one that will deliver the competitive advantage to airports, because of the introduction of new technologies together with changes in processes. Technology on its own will not deliver the benefits that airports expect to receive. For example, an airport that decided to implement self-service kiosks, but due to lack of space at the terminal the kiosks were placed in areas where access was limited. The result was that these kiosks were seldom utilised, thus not delivering the expected results of higher throughput.

The evolution of the business and changes in the governance and management structures, and the introduction of other industries' best practices, aimed to improve operational and financial performance of the airport. The survey showed that 63.43% of the CIOs report directly to the CEO, which means IT is now under the responsibility of senior management at an airport. This in turn means the strategic role of IT may also evolve. According to Chun and Mooney (2009), the role of the CIO will evolve to be one that focuses on strategy and processes, and the other a technical role that focuses on cost reductions.

The continued challenges that the industry faces, such as the increase in passenger growth, constrained infrastructure and technology changes, mean that the role of IT must evolve at the same pace so that it continues to enable an airport meet its operational obligations.

### **6.2.2 Benchmarking – the passenger at the centre**

The implications of the findings of this research is measurement of performance, which is now focusing on passenger satisfaction, and that the ASQ is becoming a commonly adopted tool to measure airport performance.

Airports now have at their disposal a large amount of performance indicators to choose from, with industry bodies such as ACI, IATA and ACRP providing guidelines to assist airports in defining and choosing the performance suited to their needs.

Airports (66% of the respondents) indicated the use of Service Level Agreements as a tool to measure airport performance, with baggage processing time as the area in which airports have an SLA in place. This is followed by passenger processing time and aircraft processing time.

From an industry perspective, the benchmarking activity is still a challenge due to lack of data, which means applying different methodologies (e.g. DEA, TFP and VFP) to overcome such a challenge. During the interviews with airport managers, it was clear that these methodologies are not used to monitor performance from day-to-day operations, and some did not know they

existed. The question that remains unanswered is how to make methodologies such as DEA accessible to airport managers.

Terminal managers are concerned about ensuring passenger, bag, cargo, and aircraft are quickly and efficiently handled. Hence, benchmarks such as ACI ASQ, DKMA Airport Consumer Surveys (ACS), and others are closer to reality for terminal managers who can use the information to improve their operations.

This research was not aimed to determine the relationship between IT and ASQ performance indicators. However, Table 23 was created in attempt to map the major areas of ASQ against technology solutions, which could help in future research of establishing a relationship between IT and ASQ.

For example, the Overall Passenger Satisfaction of ASQ whose main driver is the overall passenger satisfaction with the airport and the IT solutions that can help the airport to improve overall satisfaction is via a pro-active monitoring of the passenger journey through the airport with a dashboard showing key operational areas, and combined with business intelligence with predictive analytics to identify future outcomes (e.g. passenger congestion build-up based on specific flight profile – arrival of two or more A380 at the same time). So, airports armed with this information will be able to predict potential issues and pro-actively manage the airport's day-to-day operations thus ensuring a seamless passenger journey.

Another example is the Airport Environment (i.e. cleanliness of the airport), which can be monitored in real-time with instant feedback systems. For example, at Changi Airport (Nur, 2013) passengers can rate their satisfaction of the services (e.g. immigration services) as the process is finished or rate the cleanliness of the toilet facilities by using an Instant Feedback System that allow the monitoring of the service quality in real-time.

Areas	Drivers of Satisfaction	IT Solutions
Overall Passenger Satisfaction	Overall satisfaction with the airport	Airport Dashboard Business Intelligence Passenger Monitoring and tracking
Check-in	Efficiency of check-in staff	End-to-end passenger & bag processing (e.g. common use self-service, automated bag drop)
Security	Passport and visa inspection	eVisas, biometric identification, integrated airport systems
Way finding	Ease of finding your way through airport	FIDS, augmented reality, integrated airport solutions
Airport Facilities	Courtesy, helpfulness of airport staff	Airport CRM / Airport Dashboard / Business Intelligence
Access	Parking facilities	Airport CRM / Airport Dashboard / Business Intelligence
Arrival	Speed of baggage delivery service	Integrated end-to-end baggage processing
Airport Environment	Cleanliness of airport terminal	Instant Feedback Systems integrated with Facilities Management System

**Table 23. Mapping of ASQ areas with technology.**

Source. Author based on work for SITA.

Therefore, Table 23 could be used in future research in establishing a relationship between IT and ASQ.

### 6.2.3 IT investments

The fact that IT investment has no impact on airport performance is a result that merits further study in the industry. The CIO of a Northeast Asian airport mentioned that looking at the spend on investments alone is misleading, because total spend does not really indicate whether the investment is effective. The CIO suggested that other factors may be considered when researching the impact of investment on airport performance; for example, governance because it stipulates how systems are procured and where resources are targeted.



According to the SITA IT Trends survey, the three areas driving IT investment are: passenger, cost reductions of operations and airport operations, with passenger being the only area that was common over three years as shown in Table 24.

Areas of Investment	Y2012	Y2013	Y2014
	IT Spend 4.9%	IT Spend 4.41%	IT Spend 5.82%
Passenger Experience	59%	68%	59%
Cost reduction of operations	43%	39%	
New Products & Services	35%		
Security		38%	47%
Airport operations			33%

**Table 24. SITA Airport IT Trends survey – drivers of investment.**

The interesting aspect about the investment area in passengers is that they differ from year to year; for example, in 2014 the driver was passenger processing, 2013 was passenger experience and 2012 was passenger experience.

The online survey for this research was sent out in 2014 and, based on the results, airport operations (weighted average of 4.51) was the top investment area that will drive airport performance, followed closely by passenger and baggage processing (weighted average of 4.4), and airport security (weighted average of 4.13); these areas are the same areas reported in the SITA IT Trends survey.

The survey results also show commercial solutions (e.g. point of sales applications and car parking) as an area of priority. This reflects the industry focus on increasing non-aeronautical revenues, and areas in which airports do not traditionally invest in because these services are operated under concession. But an area that will have significant implications is Business Intelligence, particularly in two areas: operations and service improvement.

## 6.2.4 Technology

The last of the implications of the findings is regarding technology that encompasses airport systems. The selected systems used in the questionnaire are all operational systems, with Flight Information Display Systems (FIDS) having the highest weighted average (4.71), then Shared Infrastructure (CUTE & CUSS, 4.54), Airport Operational Database (AODB, 4.43), Automated Baggage Handling and Reconciliation System (BHS, BRS, 4.33), Resource Management System (RMS, 4.06), and Airport Collaborative Decision Making (A-CDM, 3.78).

Airports will have, as a minimum, FIDS and BHS. For some airports, FIDS will also serve as the AODB, because it stores flight information data. Solutions such as shared infrastructure for check-in or self-service depends on the type of operations and the airlines. For solutions, such as RMS and BRS, it depends on the level of automation the airport requires; depending on the size of the airport, it is possible to carry out manual baggage reconciliation and use Excel for simple resource allocation.

The findings revealed that RMS was the only system that did not show a significant relationship with airport performance. RMS is one solution that is expected to have a significant relationship with airport performance, because it ensures that the resources of an airport are correctly allocated, enabling the airport to maximise utilisation of key assets such as gates, counters and baggage belts.

For airport managers, particularly outside Europe, the solution could be A-CDM. This is because it integrates systems and processes of Air Traffic Control with Terminal Operations (landside and airside), with the focus on aircraft turnaround and pre-departure processes, creating a truly collaborative environment with data exchanged in real time. In Europe, Eurocontrol is driving the implementation and certification of airports under the Single Sky legislation.

### **6.2.5 Limitations of the research**

The author acknowledges this research presents some limitations, despite efforts to minimise the effects of such limitations.

The study focuses on establishing the relationship between IT and airport performance, and creates a framework to test and determine this relationship. To create the framework underlying assumptions are made, which may limit this research.

The initial idea was to study IT intensity (i.e. ratio of the airport's IT spend relative to the airport's total revenue) and its impact on airport performance, but the difficulty in obtaining financial data and IT spend meant changing to a different parameter.

The revenue information is not readily available in the public domain, and when they are available there are the variances in the reporting of the revenues (i.e. aggregate as total revenue or separated reporting showing total operating revenue). The use of the aggregated total revenue is considered.

The framework has been created with the assumption that there was no restriction regarding geographical location, ownership or size. This means that the population is very spread.

Inconsistency in the reporting of technical data, and for paid-for subscriptions, means there could be differences in size and facilities (e.g. number of gates, number of counters, terminal size and other terminal- related information). Assumptions were made to choose one database over the other, but efforts were made to compare different data with other sources (e.g. the airport's website). In this case, preference was given to the airport's website.

Although there are no technical questions (e.g. about configurations or platforms), a number of respondents replied indicating that because it was IT-related and outside their domain, they would not respond or, as happened in some cases, pass the survey to IT.

The framework also assumes that some of the mission-critical systems, such as passenger processing or baggage handling, are considered to be the responsibility of the airport. This is because, for example, in the case of passenger processing, commonly the airport provides the infrastructure (i.e. the desks) but the actual handling of passengers is done either directly by the airline or by a ground handler.

The framework is data-intensive, because it requires ownership structure as minimum, financial data (e.g. revenues), passenger volume, cargo volume and aircraft movements. In addition, to minimise drop-out rates, this information is collected outside the survey.

Despite the limitations, the findings have demonstrated the relationship between IT and airport performance. And the developed framework is repeatable and replicable.

### **6.2.6 Contributions to the body of knowledge**

The airport business continues to evolve, resulting in different ownership structures. Airports are adopting new commercial models to increase their non-aeronautical revenues (i.e. focusing on retail activities), and new strategies such as passenger-centric strategies focusing on the passenger journey throughout the airport and adopting new technologies to enable the achievement of their business objectives. IT is playing an important role in changing processes, particularly on the passenger processing front, with the adoption of self-service solutions. Furthermore, IT is being deployed to improve the operational performance of an airport, as well as reducing the costs of operations through automation.

However, despite these benefits to airports, there are few studies in the domain of IT and airport performance. Therefore, this research aims to contribute to the body of knowledge by assessing the relationship between IT and airport performance.

The research proved that it contributes to the body of knowledge by addressing the following areas:

**Research areas:** IT culture: using three factors (i.e. role, importance and benefits of IT) to determine their impact on airport performance. Airport characteristics such as ownership, management preferences to use SLA and outsourcing, and airport competitiveness and its impact on IT culture.

IT investment: to assess the impact of IT investments and airport performance, a subject highly relevant considering the steady growth on IT investment, by using or enhancing the model adapted from other industries' research on IT investment and firm's performance.

**Method:** Drawing from other industries and studies, a conceptual framework (Figure 17) was developed to test the relationship between IT and airport performance. In addition, a new method was developed that incorporates a strategic framework model (Diamond-E) to determine the airport characteristics that have an impact on airport performance. The airport characteristics are internal capabilities (i.e. management, resources and organisation) and the external environment.

**Airport trending issues:** Looking at the current trending issue of improving passenger processing and, in the context of this research, showing how technology can help airports address it. This research hopes to facilitate further research in the area of airport IT systems, airport operations and airport performance through the deployment of the conceptual framework.

**Other stakeholders (e.g. technology vendors):** this research validates some of the assumptions (e.g. IT improves operational performance of an airport, it improves financial performance by reducing costs and it increases airport's competitiveness) made by airport technology vendors on the impact of their systems on airport performance.

### **6.3 Recommendations for future research**

This study started with a broad approach and, despite its limitations, it established the relationship between IT and airport performance. However, the recommendations for future research are too narrow the focus to very specific areas of IT and performance by addressing some of findings. To deal with

issues related to data availability, the recommendation is to focus on regions where information can be more readily available (e.g. North America or Europe). However, Europe has different ownership structures to North America.

#### IT culture – Cross-cultural management – Airport performance

- I. It was not an objective of this study to focus on how culture drives decisions related to IT. In the original study, the term IT culture was used to reflect the three aspects of IT (i.e. role, importance and benefits), and in a very simplistic way, and to view them as shared values, beliefs and norms regarding IT and its adoption (Gallivan and Srite, 2005). However, as the airport business becomes global, airport operators are expanding their reach (e.g. Singapore Changi in Brazil) and there is a strong push for collaboration (e.g. A-CDM), bringing standardised solutions and processes to people from different cultures.
- II. Therefore, research is needed to understand how cross-cultural airport management can be mediated through IT solution to improve performance.
- III. The IT function, despite gaining strategic importance, in some cases is not part of the senior management structure of an airport. The question is whether the results from the study carried out by Li and Ye (1999), which showed evidence of a positive impact on performance as result of a closer tie between the CEO and CIO, will be valid to an airport.

#### IT culture – IT outsourcing – Airport performance

- I. In the original study, only the relationship between IT culture and outsourcing was tested. However, there is a recommendation to narrow the scope of outsourcing in two steps: (1) to determine the main reasons for outsourcing a function or department, (2) to consider IT outsourcing mediated by IT culture and its impact on airport performance.

## IT investment – Airport performance

- I. The findings show that there is no significant relationship between IT investment and airport performance. However, other aspects should be considered, such as airport characteristics, which according to Kim and Jee (2007) in their results show that IT investment is influenced by competition.

The final recommendation is to research a way to make airport benchmarking more attainable to airport operations.

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# APPENDICES

## Appendix A - Mapping of Performance Indicators: Traditional, ACI, and ACRP

Table 25. Mapping of Traditional Performance Indicators against ACI’s 42 indicators and ACRP’s 29 core performance indicators

Performance Areas		Performance Indicators		
		ACI (2012)	ACRP (2011)	Traditional (1999)
Core	Operations	<ul style="list-style-type: none"> <li>• Passenger</li> <li>• Origin and Destination Passenger</li> </ul>	<ul style="list-style-type: none"> <li>• Passenger flights</li> </ul>	<ul style="list-style-type: none"> <li>• Annual Terminal Passengers or Total Annual Traffic</li> <li>• Annual International Passengers as a Percentage of Total Traffic</li> <li>• Total Passenger per Movement</li> <li>• Annual Work Load Unit (WLU)</li> </ul>
	Aircraft	<ul style="list-style-type: none"> <li>• Aircraft Movements</li> </ul>	<ul style="list-style-type: none"> <li>• Aircraft Operations</li> <li>• Enplanements</li> </ul>	<ul style="list-style-type: none"> <li>• Air Transport Movements</li> </ul>
	Freight / Mail	<ul style="list-style-type: none"> <li>• Freight or Mail Loaded/Unloaded</li> </ul>	<ul style="list-style-type: none"> <li>• Cargo Tons</li> </ul>	<ul style="list-style-type: none"> <li>• Annual Cargo Tons</li> </ul>
	Destination	<ul style="list-style-type: none"> <li>• Destinations – nonstop</li> </ul>	<ul style="list-style-type: none"> <li>• Nonstop destinations</li> </ul>	
Safety & Security	Runways	<ul style="list-style-type: none"> <li>• Runways Accidents</li> <li>• Runways Incursions</li> <li>• Bird Strikes</li> </ul>	<ul style="list-style-type: none"> <li>• Runways Incursions</li> </ul>	
Safety & Security	People	<ul style="list-style-type: none"> <li>• Occupational Injuries</li> <li>• Lost Work Time from Employee Accidents and Injuries</li> </ul>	<ul style="list-style-type: none"> <li>• Employee Accidents and Injuries – Lost Work Days</li> </ul>	
	Others	<ul style="list-style-type: none"> <li>• Public Injuries</li> </ul>		

Performance Areas		Performance Indicators		
		ACI (2012)	ACRP (2011)	Traditional (1999)
Service Quality	Service & Facilities	<ul style="list-style-type: none"> <li>• Practical Hourly Facilities (max aircraft movement per hour)</li> <li>• Gate Departure Delay</li> <li>• Taxi Departure Delay</li> <li>• Customer Satisfaction</li> <li>• Baggage Delivery Time</li> <li>• Security Clearing Time</li> <li>• Border Control Clearing Time</li> <li>• Check-in to Gate Time</li> </ul>	<ul style="list-style-type: none"> <li>• Customer Satisfaction with Airport</li> <li>• 11 other indicators are proposed under the Key Category</li> </ul>	
Productivity / Cost Effectiveness	Labour	<ul style="list-style-type: none"> <li>• Passengers per Employee</li> <li>• Aircraft Movements per Employee</li> </ul>		<ul style="list-style-type: none"> <li>• WLU per Employee</li> </ul>
	Infrastructure	<ul style="list-style-type: none"> <li>• Aircraft Movements per Gate</li> </ul>		<ul style="list-style-type: none"> <li>• Asset Value per Employee</li> </ul>
Productivity / Cost Effectiveness	Cost Performance	<ul style="list-style-type: none"> <li>• Total Cost per Passenger</li> <li>• Total Cost per Movement</li> <li>• Total Cost per WLU</li> <li>• Operating Cost per Passenger</li> <li>• Operating Cost per Movement</li> <li>• Operating Cost per WLU</li> </ul>	<ul style="list-style-type: none"> <li>• Airline Cost per Enplanement</li> <li>• Airport Cost per Enplanement</li> <li>• M/W/DBE<sup>29</sup> Participation Rate</li> <li>• Salary + Wages + Benefits Cost as percentage of Total Operating Cost</li> <li>• Salary + Wages + Benefits Cost per Airport Employee</li> <li>• Operating Cost per Enplanement</li> <li>• Construction Projects – actual vs. budgeted costs</li> </ul>	<ul style="list-style-type: none"> <li>• Total Costs per WLU</li> <li>• Total Costs per Movement</li> <li>• Operating Cost per WLU</li> <li>• Capital Cost per WLU</li> <li>• Staff Cost per WLU</li> <li>• Capital Costs as a percentage of Total Costs</li> <li>• Staff Cost as a percentage of Total Costs</li> </ul>

<sup>29</sup> M/W/DBE: Minority, Women, and Disadvantaged Business Enterprise

Performance Areas		Performance Indicators		
		ACI (2012)	ACRP (2011)	Traditional (1999)
Financial / Commercial	Commercial	<ul style="list-style-type: none"> <li>• Non-Aeronautical Operating Revenue as Percent of Total Operating Revenue</li> <li>• Non-Aeronautical Revenue per Passenger</li> </ul>	<ul style="list-style-type: none"> <li>• Non-Aeronautical Operating Revenue per Enplanement</li> <li>• Non-Aeronautical Operating Revenue as a Percentage of Total Operating Revenue</li> <li>• Concession Revenue to the airport as Percentage of Total Operating Revenue</li> <li>• Concession Revenue to the Airport per Enplanement</li> <li>• Rental Car Revenue to the airport per Destination Passenger</li> <li>• Parking Revenue to the Airport per Originating Passenger</li> <li>• General Aviation: <ul style="list-style-type: none"> <li>• Based Aircraft</li> <li>• Fuel Use/Sales</li> <li>• Hangar Rental and Ground Lease Income</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>• Non-Aeronautical Revenue per WLU</li> <li>• Commercial Revenue per Passenger</li> </ul>

Performance Areas		Performance Indicators		
		ACI (2012)	ACRP (2011)	Traditional (1999)
Financial / Commercial	Financial	<ul style="list-style-type: none"> <li>• Aeronautical Revenue per Passenger</li> <li>• Aeronautical Revenue per Movement</li> <li>• Debt Service as Percentage of Operating Revenue</li> <li>• Long-Term Debt per Passenger</li> <li>• Debt to EBITDA Ratio</li> <li>• EBITDA per Passenger</li> </ul>	<ul style="list-style-type: none"> <li>• Landing Fee Rate</li> <li>• Days Unrestricted Cash on Hand</li> <li>• Debt per Enplanement</li> <li>• Debt Service Coverage Ratio</li> <li>• Bond Rating</li> </ul>	<ul style="list-style-type: none"> <li>• Total Revenue per Employee</li> <li>• Net Profit</li> <li>• Net Profit per WLU</li> <li>• Revenue-Expenditure Ratio</li> <li>• Current Ratio</li> <li>• Operating Ratio</li> <li>• Total Revenue per WLU</li> <li>• Aeronautical Revenue per WLU</li> <li>• Aeronautical Revenue as a percentage of Total Revenue</li> <li>• Total Revenue per Asset Value</li> </ul>
	Environmental	<ul style="list-style-type: none"> <li>• Carbon Footprint</li> <li>• Waste Recycling</li> <li>• Waste Reduction Percentage</li> <li>• Renewable Energy Purchased by the Airport (percentage)</li> <li>• Utilities/Energy Usage per Square Metre of Terminal</li> <li>• Water Consumption per Passenger</li> </ul>	<ul style="list-style-type: none"> <li>• 11 performance indicators are proposed under Key category but none in the Core category.</li> </ul>	

## Appendix B - Studies on IT and airport performance

Based on the literature reviewed by the author, Table 26, was created to list studies in the airport industry focused on IT.

**Table 26. IT related studies in the airport industry.**

Author	Year	Description	Airport Domain	Technology	Findings
Yan, S.; Tang, C.H.; Chen, M.	2004	A model and a solution algorithm for airport common use check-in counter assignments	<ul style="list-style-type: none"> <li>• Check-in</li> </ul>	<ul style="list-style-type: none"> <li>• Resource Management</li> <li>• Common Use Check-in</li> </ul>	<ul style="list-style-type: none"> <li>• The paper proposed the development of a model to assist airports to allocate common use check-in counters.</li> <li>• The preliminary results of the model tested at Taoyuan Airport (formerly known as Chiang Kai Shek (CKS) Airport) in Taiwan showed the potential usefulness of the solution but further tests should be conducted.</li> </ul>
Zografos, K. G. Madas, M. A	2006	Development and demonstration of an integrated decision support system for airport performance analysis	<ul style="list-style-type: none"> <li>• Operations</li> </ul>	<ul style="list-style-type: none"> <li>• Airport Management</li> <li>• Resource Management</li> </ul>	<ul style="list-style-type: none"> <li>• The paper provides the results of the implementation of an integrated decision support model (OPAL DSS).</li> <li>• OPAL DSS is a simulation tool that provides airports with planning capabilities by taking into account “what if” scenarios and their impacts on airport operations.</li> <li>• The results indicate that OPAL DSS can be efficiently used to plan and support real-life airport operations.</li> </ul>

Author	Year	Description	Airport Domain	Technology	Findings
Jiang, H.	2006	Internet technology and airport economic performance	<ul style="list-style-type: none"> <li>• Management</li> </ul>	<ul style="list-style-type: none"> <li>• Internet</li> </ul>	<ul style="list-style-type: none"> <li>• The objective is to review the improvement through Internet Technology.</li> <li>• The paper shows that Internet Technology can impact the airport economic performance.</li> <li>• The paper also indicates the need for solutions to improve the passenger journey to result in more non-aeronautical revenues.</li> </ul>
Nucciarelli, A. Gastaldi, M.	2007	Collaboration in the airport business through the development of an IT platform	<ul style="list-style-type: none"> <li>• Commercial / Marketing</li> </ul>	<ul style="list-style-type: none"> <li>• E-Commerce</li> <li>• Website</li> </ul>	<ul style="list-style-type: none"> <li>• The paper proposed the creation of an IT platform (Travel Information-based Exchange – TIE) to foster collaboration between airports and other stakeholders, and to meet new market demands.</li> <li>• The results of data collected from the site of Abruzzo International Airport confirms the creation and implementation of an integrated TIE platform.</li> </ul>
Assaf, A.	2009	Accounting for size in efficiency comparisons of airports	<ul style="list-style-type: none"> <li>• Management</li> </ul>	<ul style="list-style-type: none"> <li>• Technology</li> </ul>	<ul style="list-style-type: none"> <li>• This paper uses technology as a frontier to measure efficiency of large and small airports.</li> <li>• The results shows that large airports outperform small airports.</li> </ul>
Barros, C. P. Weber, W. L.	2009	Productivity growth and biased technological change in UK airports	<ul style="list-style-type: none"> <li>• Management</li> </ul>	<ul style="list-style-type: none"> <li>• Technology</li> </ul>	<ul style="list-style-type: none"> <li>• This paper estimates the total factor productivity of UK airports against an index of efficiency change and technological change.</li> <li>• The result ranks airports according to their productivity</li> </ul>



Author	Year	Description	Airport Domain	Technology	Findings
					change, which showed average decreases in productivity.
Zografos, K. G.; Manataki, I. E.	2009	A generic system dynamics based tool for airport terminal performance analysis	<ul style="list-style-type: none"> <li>• Operations</li> </ul>	<ul style="list-style-type: none"> <li>• Airport Management</li> <li>• Resource Management</li> </ul>	<ul style="list-style-type: none"> <li>• The paper proposes a model to analyse the terminal performance and to support decision-making.</li> <li>• Athens Airport provided real data to test the model</li> <li>• Ability to explore a wide range of what-if scenarios, which in turn supports more effective decision-making in airport terminal</li> </ul>
Klann, D.	2009	The Role of Information Technology in the Airport Business: A Retail-Weighted Resource Management Approach for Capacity-Constrained Airports	<ul style="list-style-type: none"> <li>• Operations</li> </ul>	<ul style="list-style-type: none"> <li>• Resource Management</li> </ul>	<ul style="list-style-type: none"> <li>• The research proposes that an alignment between business and IT functions will improve firm's performance.</li> <li>• The alignment of gate allocation and airport retail.</li> <li>• The model demonstrated it is possible to increase retail sales.</li> </ul>
Sohn, S-C, Kim, K-W. Lee, C.	2013	User Requirement Analysis and IT Framework Design for Smart Airports	<ul style="list-style-type: none"> <li>• Operations</li> </ul>	<ul style="list-style-type: none"> <li>• Mobile applications</li> <li>• IT Systems</li> </ul>	<ul style="list-style-type: none"> <li>• It proposes a framework ("Smart Airport Service") for faster passenger service, improvement in work processes and resource utilisation.</li> <li>• The results obtained from a simulation and survey indicate significant improvement in boarding, reduction of stress and security.</li> </ul>
Phy, J. L.	2014	Airport IT: Enabler of the long-term vision or insurmountable obstacle	<ul style="list-style-type: none"> <li>• Management</li> </ul>	<ul style="list-style-type: none"> <li>• Technology</li> </ul>	<ul style="list-style-type: none"> <li>• It proposes that airport operators can achieve their long-term</li> </ul>

Author	Year	Description	Airport Domain	Technology	Findings
					<p>strategic objectives by leveraging technology.</p> <ul style="list-style-type: none"> <li>• It also proposes the need of governance to ensure alignment between IT and the business objectives, which will enable the IT organisation to support the airport's long-term objectives.</li> </ul>
Kalakou, S, Psaraki0Kalouptsidi, V. Moura, F.	2014	Future airport terminals: new technologies promise capacity gains	<ul style="list-style-type: none"> <li>• Operations</li> </ul>	<ul style="list-style-type: none"> <li>• Biometrics</li> <li>• Near Field Communications (NFC)</li> <li>• Big Data Analytics</li> <li>• Mobile applications</li> </ul>	<ul style="list-style-type: none"> <li>• A simulation model is developed to assess the impact of technology (biometric systems, NFC, Big Data and mobile applications) on terminal design.</li> <li>• The significant result is the reduction in processing time at check-in and security checkpoints, which resulted in capacity gains and put into question the need for a terminal expansion.</li> </ul>

## Appendix C - Original Questionnaire

The original questionnaire used was on Cranfield University letterhead:



This survey is aimed at obtaining the following information:

1) To determine the role of IT within an airport and to classify it in one of the following categories:

- Strategic – active role in defining the company's strategic goals
- Operational – improve operational efficiency of the business
- Custodian – responsible for the all technology-matters of the airport business, including security and governance
- Transformational – deployment of technology to transform the organisation

2) The role of IT

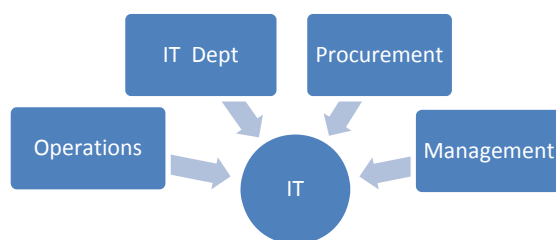
3) To determine what matters to an airport, i.e., the expected IT benefits

4) Where IT fits in the airport organisational structure in terms of reporting line

5) How IT is procured and deployed by airports

6) Procurement of specific solutions: Self-Service / Airport Resource Management System / Airport Collaborative Tools / Airport Management System

The survey is aimed at providing a wider view of the IT. Therefore, the survey will be conducted by interviewing different parts of the organisations.



The Role of IT

**1. How do you classify IT? Please rank from the highest to the lowest priority.**

	5 = Very High	4 = High	3= Medium	2= Low	1= Not a priority
Strategic - active role in defining the company's strategic goals	<input type="checkbox"/> 5	<input type="checkbox"/> 4	<input type="checkbox"/> 3	<input type="checkbox"/> 2	<input type="checkbox"/> 1
Operational - improve operational efficiency of the business	<input type="checkbox"/> 5	<input type="checkbox"/> 4	<input type="checkbox"/> 3	<input type="checkbox"/> 2	<input type="checkbox"/> 1
Custodian - responsible for the all technology-matters of the airport business, including security and governance	<input type="checkbox"/> 5	<input type="checkbox"/> 4	<input type="checkbox"/> 3	<input type="checkbox"/> 2	<input type="checkbox"/> 1
Transformational - deployment of technology to transform the organisation	<input type="checkbox"/> 5	<input type="checkbox"/> 4	<input type="checkbox"/> 3	<input type="checkbox"/> 2	<input type="checkbox"/> 1

**1A. Please explain the reasons for the ranking.**

<b>2. What role does IT play?</b>	5 = Very High	4 = High	3= Medium	2= Low	1= Not a priority
Mission Critical	<input type="checkbox"/> 5	<input type="checkbox"/> 4	<input type="checkbox"/> 3	<input type="checkbox"/> 2	<input type="checkbox"/> 1
Key growth	<input type="checkbox"/> 5	<input type="checkbox"/> 4	<input type="checkbox"/> 3	<input type="checkbox"/> 2	<input type="checkbox"/> 1
Product or service enhancement	<input type="checkbox"/> 5	<input type="checkbox"/> 4	<input type="checkbox"/> 3	<input type="checkbox"/> 2	<input type="checkbox"/> 1
Company's training needs in use of technology	<input type="checkbox"/> 5	<input type="checkbox"/> 4	<input type="checkbox"/> 3	<input type="checkbox"/> 2	<input type="checkbox"/> 1
Organisational needs	<input type="checkbox"/> 5	<input type="checkbox"/> 4	<input type="checkbox"/> 3	<input type="checkbox"/> 2	<input type="checkbox"/> 1
IT plays an important role in the airport.	<input type="checkbox"/> 5	<input type="checkbox"/> 4	<input type="checkbox"/> 3	<input type="checkbox"/> 2	<input type="checkbox"/> 1
IT has a positive contribution to the performance of the airport.	<input type="checkbox"/> 5	<input type="checkbox"/> 4	<input type="checkbox"/> 3	<input type="checkbox"/> 2	<input type="checkbox"/> 1

**2A. Please expand and explain your choices.**

**3 A. What are the expected benefits? Please select the most important benefit.**

	5 = Very Important	4 = Fairly Important	3= Important	2= Slightly Important	1= Not at all Important
"IT transforming potential" do things differently and to be become more competitive	<input type="checkbox"/> 5	<input type="checkbox"/> 4	<input type="checkbox"/> 3	<input type="checkbox"/> 2	<input type="checkbox"/> 1

“IT associated economics” – cost reductions	<input type="checkbox"/> 5	<input type="checkbox"/> 4	<input type="checkbox"/> 3	<input type="checkbox"/> 2	<input type="checkbox"/> 1
“Business Intelligence”	<input type="checkbox"/> 5	<input type="checkbox"/> 4	<input type="checkbox"/> 3	<input type="checkbox"/> 2	<input type="checkbox"/> 1
“Differentiation”	<input type="checkbox"/> 5	<input type="checkbox"/> 4	<input type="checkbox"/> 3	<input type="checkbox"/> 2	<input type="checkbox"/> 1
“Innovation”	<input type="checkbox"/> 5	<input type="checkbox"/> 4	<input type="checkbox"/> 3	<input type="checkbox"/> 2	<input type="checkbox"/> 1

**3B. The measurement of IT performance.**

3B1. How do you measure IT performance?

3B2. How does the rest of the organisation measure IT performance

3B3. What are the KPIs used?

3B4. How these were determined?

**3C. The measurement of performance.**

3C1. Does the airport use other Performance Indicators? If yes, please indicate them.

3C2. How many are related to IT?

3C3. How are they related to IT?

3C4. Other comments

**4. Organisational fit.**

4 A. Where does IT fit in the organisational structure of the airport?

4B. Is IT a business unit on its own?

4C. Can you please provide a copy of the airport and IT org chart?

4D. Does the CIO report to the CEO? If not, to whom does the CIO report to?

**5. IT Procurement process**

5A. Which department is responsible for the process?

Purchasing Dept  IT Dept  Finance  Operations

5B. Can you please describe the procurement process of IT?

**6. Solution specific and its performance:**

**(a) Self-Service | (b) Resource Mgmt Sys (RMS) | (c) A-CDM | (d) Airport Mgmt Sys (AMS)**

6A. How much was invested on each of the above solutions?

Self-Service:

RMS:

A-CDM:

AMS:

6B. What was the reduction in turnaround time by deploying the solutions above?

Self-Service:

RMS:

A-CDM:

AMS:

6C. What are the KPI set for these solutions?

Self-Service:

RMS:

A-CDM:

AMS:

6D. Did other stakeholders (airlines, ground handlers, government agencies, etc) get involved in the procurement of the solution(s)? Please indicate the stakeholder.

Self-Service:

RMS:

A-CDM:

AMS:

6E. Did other stakeholders (airlines, ground handlers, government agencies, etc) get involved in the decision process? Please indicate the stakeholder.

Self-Service:

RMS:

A-CDM:

AMS:

Other comments?

IT-Intensity of the airport industry

The objective of this portion of the research is to determine the following:

IT-Intensity: defined as the ratio of the airport's IT spend relative to the airport's total revenue.



Identify key investment areas

Determine the IT posture of the airport: governance, access to resources, and skills

Determine how intensely the airport consumes IT

## 7. IT-Intensity

7A. Airport Name:

7B. Airport Ownership:  Private  Public  Mixed  Corporatised

N.B.: Corporatised airport: allocation of the non-regulatory functions of the airport under a new airport company, which will undertake the operational functions of managing the airport.

7C. Number of passengers handled, and if applicable, split into domestic and international:

2011: (Dom:            ) | (Int:            )

2010: (Dom:            ) | (Int:            )

2009: (Dom:            ) | (Int:            )

2008: (Dom:            ) | (Int:            )

7D. Airport Revenue and Expenses:

Total Revenue:

2011: \_\_\_\_\_

2010: \_\_\_\_\_

2009: \_\_\_\_\_

2008: \_\_\_\_\_

7E. Total Operating Expenses:

2011: \_\_\_\_\_

2010: \_\_\_\_\_

2009: \_\_\_\_\_

2008: \_\_\_\_\_

7F. IT Spend

Total IT spend (as % of revenue) in

2011: \_\_\_\_\_ %

2010: \_\_\_\_\_ %

2009: \_\_\_\_\_ %

2008: \_\_\_\_\_ %

Total IT spend (as % of operating expenses) in

2011: \_\_\_\_\_ %

2010: \_\_\_\_\_ %

2009: \_\_\_\_\_ %

2008: \_\_\_\_\_ %

What are the major IT costs?

2011:

Applications: % | Infrastructure: % | Telco: % | Personnel: % | Other:  
%

2010:

Applications: % | Infrastructure: % | Telco: % | Personnel: % | Other: %

2009:

Applications: % | Infrastructure: % | Telco: % | Personnel: % | Other: %

2008:

Applications: % | Infrastructure: % | Telco: % | Personnel: % | Other: %

Please give an approximation if the exact percentage is not available. Please consider IT spend to include staff, service contracts & depreciation of assets

**8. Please identify key investment areas in IT**

	5 = Very Important	4 = Fairly Important	3 = Important	2 = Slightly Important	1 = Not at all Important
Passenger & Baggage processing & related services	<input type="checkbox"/> 5	<input type="checkbox"/> 4	<input type="checkbox"/> 3	<input type="checkbox"/> 2	<input type="checkbox"/> 1
Runway operations	<input type="checkbox"/> 5	<input type="checkbox"/> 4	<input type="checkbox"/> 3	<input type="checkbox"/> 2	<input type="checkbox"/> 1
Airport operations (management of resources, schedules etc)	<input type="checkbox"/> 5	<input type="checkbox"/> 4	<input type="checkbox"/> 3	<input type="checkbox"/> 2	<input type="checkbox"/> 1
Environmental initiatives	<input type="checkbox"/> 5	<input type="checkbox"/> 4	<input type="checkbox"/> 3	<input type="checkbox"/> 2	<input type="checkbox"/> 1

Airport security e.g. identity verification, employee access	<input type="checkbox"/> 5	<input type="checkbox"/> 4	<input type="checkbox"/> 3	<input type="checkbox"/> 2	<input type="checkbox"/> 1
Business Intelligence (Airport CDM)	<input type="checkbox"/> 5	<input type="checkbox"/> 4	<input type="checkbox"/> 3	<input type="checkbox"/> 2	<input type="checkbox"/> 1
Business Support Functions, e.g., HR, Finance, etc	<input type="checkbox"/> 5	<input type="checkbox"/> 4	<input type="checkbox"/> 3	<input type="checkbox"/> 2	<input type="checkbox"/> 1
Commercial: restaurants (F&B), retail, car parking, etc	<input type="checkbox"/> 5	<input type="checkbox"/> 4	<input type="checkbox"/> 3	<input type="checkbox"/> 2	<input type="checkbox"/> 1

### 9. Airport Characteristics

These are questions related to management, resources, and environment characteristics of an airport.

<b>9A. Management:</b> Which of the following best describes your organization?					
	5= Strongly agree	4 = Agree	3= Neither agree or disagree	2= Disagree	1= Strongly Disagree
Service Levels are an important element to measure airport performance.	<input type="checkbox"/> 5	<input type="checkbox"/> 4	<input type="checkbox"/> 3	<input type="checkbox"/> 2	<input type="checkbox"/> 1
IT Solutions are procured to ensure Service Levels are maintained.	<input type="checkbox"/> 5	<input type="checkbox"/> 4	<input type="checkbox"/> 3	<input type="checkbox"/> 2	<input type="checkbox"/> 1
There are Service Level Agreements related to Passenger Processing time	<input type="checkbox"/> 5	<input type="checkbox"/> 4	<input type="checkbox"/> 3	<input type="checkbox"/> 2	<input type="checkbox"/> 1
There are Service Level Agreements related to Baggage	<input type="checkbox"/> 5	<input type="checkbox"/> 4	<input type="checkbox"/> 3	<input type="checkbox"/> 2	<input type="checkbox"/> 1

Processing time (first bag in and out)					
There are Service Level Agreements related to Aircraft Processing time	<input type="checkbox"/> 5	<input type="checkbox"/> 4	<input type="checkbox"/> 3	<input type="checkbox"/> 2	<input type="checkbox"/> 1

**9A1. Please describe the Service Levels used by your airport, e.g., waiting time at queues, security lines, etc.**

**9A2. Please describe how these Service Levels indicators are used to measure airport performance.**

**9B. Resources:** Which of the following best describes your organization?

	5= Strongly agree	4 = Agree	3= Neither agree or disagree	2= Disagree	1= Strongly Disagree
Outsourcing is used to cover the shortage of internal resources	<input type="checkbox"/> 5	<input type="checkbox"/> 4	<input type="checkbox"/> 3	<input type="checkbox"/> 2	<input type="checkbox"/> 1
Outsourcing is currently used for most tasks and processes	<input type="checkbox"/> 5	<input type="checkbox"/> 4	<input type="checkbox"/> 3	<input type="checkbox"/> 2	<input type="checkbox"/> 1
Skilled resources are readily available in my market place	<input type="checkbox"/> 5	<input type="checkbox"/> 4	<input type="checkbox"/> 3	<input type="checkbox"/> 2	<input type="checkbox"/> 1
Skilled resources are an important element to a high performance airport	<input type="checkbox"/> 5	<input type="checkbox"/> 4	<input type="checkbox"/> 3	<input type="checkbox"/> 2	<input type="checkbox"/> 1

<b>9C. Environment:</b> Which of the following best describes your organization?					
	5= Strongly agree	4 = Agree	3= Neither agree or disagree	2= Disagree	1= Strongly Disagree
There is intense competition in your current market	<input type="checkbox"/> 5	<input type="checkbox"/> 4	<input type="checkbox"/> 3	<input type="checkbox"/> 2	<input type="checkbox"/> 1
You are constantly bringing new products/services due to competition	<input type="checkbox"/> 5	<input type="checkbox"/> 4	<input type="checkbox"/> 3	<input type="checkbox"/> 2	<input type="checkbox"/> 1
In my airport IT is used as a Competitive Advantage	<input type="checkbox"/> 5	<input type="checkbox"/> 4	<input type="checkbox"/> 3	<input type="checkbox"/> 2	<input type="checkbox"/> 1

## Appendix D – Online Questionnaire



PhD Thesis: The impact of IT on Airport Performance.

The Airport

1. What is your functional role?

- Operations
- IT
- Finance & Administration
- Commercial
- Engineering
- Legal
- Other (please specify)

2. Which of the following best describes your organisation?

	Strongly Agree	Agree	Neither Agree Nor Disagree	Disagree	Strongly disagree
There is intense competition from other airports.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Operational performance is the most important factor to ensure airport competitiveness.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Financial performance is the most important factor to ensure airport competitiveness.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Airport performance does not matter to ensure airport competitiveness.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

3. Which of the following best describes your airport?

	Strongly Agree	Agree	Neither Disagree Nor Agree	Disagree	Strongly disagree
Skilled technical and operational resources are an important element to a high performance airport.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Outsourcing is one way to improve airport performance.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Outsourcing is currently used for most tasks and processes.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

4. Does the CIO (Chief Information Officer) report directly to the CEO

- Yes
- No
- If NO: To whom does the CIO report to?



5. Please rank the priority of ICT (Information and Communications Technology) function in your airport. Please move the choices in order of preference where #1 is the top priority.

<input type="checkbox"/>	Strategic role - plays an active role in defining the airport's strategic goals.
<input type="checkbox"/>	Operational role - plays an important role to improve operational efficiency of the airport.
<input type="checkbox"/>	ICT Custodian - is responsible for all IT-related matters of the airport.
<input type="checkbox"/>	Transformational role - plays an important role to change the airport processes through deployment of technology.

6. What is the importance of ICT (Information and Communications Technology) to your airport?

	Very important.	Fairly important.	Important	Slightly important.	Not at all important.
ICT plays a mission critical role.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
ICT is key to the airport's growth.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
ICT is deployed to enhance the airport's products and services.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
ICT addresses the airport's needs for automation and technology.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
ICT has a positive contribution to the performance of the airport.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

7. Please rank the most important benefit of ICT (Information and Communications Technology). Please move the choices in order of preference where #1 is the top priority.

<input type="checkbox"/>	ICT enables the airport to do things differently and to become more competitive.
<input type="checkbox"/>	ICT helps to reduce costs.
<input type="checkbox"/>	ICT is deployed to differentiate the airport's products and services.
<input type="checkbox"/>	ICT brings innovation and encourages innovations.
<input type="checkbox"/>	ICT such as Business Intelligence technologies improve decision-making and long-term planning.

Airport Performance

*Airport performance is being defined as a systematic and iterative approach to ensure that the airport's objectives are consistently met by focusing on key areas: safety & security, service quality, productivity/efficiency, financial/commercial, and environmental.*

8. How does your airport measure performance? Please rate the importance of the measures listed below.

	Very Important	Fairly Important	Important	Slightly Important	Not at all Important
ACI Airport Service Quality Surveys (ACI ASQ).	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Traditional Airport Performance Indicators, e.g. Work Load Units (WLU), Air Transport Movements, Total Passengers Per Movement, Total Revenue per WLU, etc.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Global Airport Benchmarking by ATRS (Air Transport Research Society).	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Financial Indicators, e.g. ROI, ROIC, EBITDA, etc.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Operational Indicators, e.g. Turnaround Time, Operational Service Level Agreements (SLAs), etc.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Airport Benchmarking methodologies such as Jaxx Development Analysis, etc.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
SKYTRAX Airport Ranking	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Please specify other performance measures not included above.

9. Do you participate in the ACI ASQ Survey?

Yes.

No.

*Airport performance is being defined as a systematic and iterative approach to ensure that the airport's objectives are consistently met by focusing on key areas: safety & security, service quality, productivity/efficiency, financial/commercial, and environmental.*

10. Does your airport use the ACI ASQ Service Dimensions to improve airport performance?

- Yes.
- No.

*Airport performance is being defined as a systematic and iterative approach to ensure that the airport's objectives are consistently met by focusing on key areas: safety & security, service quality, productivity/efficiency, financial/commercial, and environmental.*

11. What are the most important dimensions of the ACI ASQ survey to your airport? Please rank in order of importance. Please move the choices in order of preference where #1 is the top priority.

<input type="checkbox"/> Overall passenger satisfaction.
<input type="checkbox"/> Check-in.
<input type="checkbox"/> Security.
<input type="checkbox"/> Finding your way through the airport.
<input type="checkbox"/> Airport Facilities.
<input type="checkbox"/> Access.
<input type="checkbox"/> Arrival.
<input type="checkbox"/> Airport Environment.

**Definition of the ACI ASQ Indicators:**

Overall Experience: the final and aggregate score of the survey

Security: ratings on courtesy, efficiency, and queuing time

Airport Facilities: restaurants & catering facilities, cleanliness of toilets of trolleys

Arrival: immigration & customs inspection and speed of bag delivery terminal

Check-in: ratings courtesy, efficiency, and queuing time

Finding your way: ease to find your way through the airport

Access to airport: ground transportation, parking, availability

Airport environment: Ambiance and cleanliness of the airport terminal

12. How important are these systems to the performance of your airport?

	Strongly Agree	Agree	Neither Disagree Nor Agree	Disagree	Strongly disagree
Shared check-in infrastructure systems (CLUE and CUSS).	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Resource Management Systems (RMS).	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Airport Operational Databases (AODS).	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Flight Information Display Systems.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Automated Baggage Handling and Reconciliation System.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Airport Collaborative Decision Making (A-CDM).	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

13. How important is the investment in IT to improve airport performance?

Very important	Fairly important	Important	Slightly important	Not at all important
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

14. Please identify key investment areas in ICT that will help the performance of your airport.

	Strongly Agree	Agree	Neither Disagree Nor Agree	Disagree	Strongly Disagree
Passenger/Baggage processing and related services.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Airport operations (management of resources, schedules, etc).	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Airport Security.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Environment initiatives (reduction in carbon footprint, etc).	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Business Intelligence (big data, Customer Relationship Management, A-CDM, etc)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Business support (HR, Finance, Marketing, etc)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Commercial (Point of sales applications, car parking, tenancy management, etc).	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

15. Please indicate if you agree with the statements below regarding the use of Service Level Agreements (SLAs) to measure airport performance.

	Strongly Agree	Agree	Neither Disagree Nor Agree	Disagree	Strongly Disagree
My airport uses SLAs as an important tool to measure airport performance.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
My airport uses SLAs to manage Passenger processing time.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
My airport uses SLAs to manage Baggage processing time.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
My airport uses SLAs to manage Aircraft processing time.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

16. My airport uses Service Level Agreements as important tool to measure airport performance.

- Yes.
- No.

17. Please indicate if you agree with the statements below regarding the use of Service Levels Agreements (SLAs) to measure airport performance.

	Strongly Agree	Agree	Neither Disagree Nor Agree	Disagree	Strongly Disagree
My airport uses SLAs to manage Passenger processing time.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
My airport uses SLAs to manage Baggage processing time.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
My airport uses SLAs to manage Aircrews' processing time.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>



## **Appendix E – Email Invitation Collector - Letters**

### **E.1 Collector: PhD Thesis Survey – sent on 09 July 2014**

FROM: c.y.kaduoka@cranfield.ac.uk via surveymonkey.com

DATE: Wednesday, July 09, 2014 2:19 PM

SENT TO: 1,706 recipients

SUBJECT: Cranfield University: PhD thesis research - request for feedback

Dear [FirstName] [LastName],

I am researching the impact of IT on Airport Performance as the subject of my doctorate thesis at Cranfield University, and I would like to invite you to participate in this academic research survey aimed to provide an insight into airports and their views on IT.

This survey will take approximately ten minutes to complete, and your response will be aggregated for analyses and whose results will be used as part of my thesis submission.

All information obtained as part of the research shall be regarded and treated as confidential.

To start the survey, click the link below:

[https://surveymonkey.com/s.aspx?sm=4mp8tw3FIHSTIkWkJpecUQ\\_3d\\_3d](https://surveymonkey.com/s.aspx?sm=4mp8tw3FIHSTIkWkJpecUQ_3d_3d)

Thank you in advance for your participation.

Carlos Y. Kaduoka, MRAeS

PS: If you have additional questions, please email c.y.kaduoka@cranfield.ac.uk

Please note: If you do not wish to receive further emails from us, please click the link below, and you will be automatically removed from our mailing list.

[https://surveymonkey.com/optout.aspx?sm=4mp8tw3FIHSTIkWkJpecUQ\\_3d\\_3d](https://surveymonkey.com/optout.aspx?sm=4mp8tw3FIHSTIkWkJpecUQ_3d_3d)

## **E.2 Collector: PhD Thesis Survey – sent on 21 August 2014**

FROM: c.y.kaduoka@cranfield.ac.uk via surveymonkey.com

DATE: Thursday, August 21, 2014 3:05 PM

SENT TO: 1,458 recipients

SUBJECT: Reminder: Cranfield University: Doctorate thesis research - request for feedback

Dear [FirstName] [LastName],

I would like to invite you to participate in this academic research survey, as part of my doctorate research, aimed to provide an insight into airports and their views on IT. If you wish to receive a copy of the aggregated results please kindly let me know.

This survey will take approximately 5 minutes to complete, and your response will be aggregated for analyses and whose results will be used as part of my thesis submission. To respond to the survey does not require you to be knowledgeable or an IT expert.

All information obtained as part of the research shall be regarded and treated as confidential.

To start the survey, click the link below:

[https://surveymonkey.com/s.aspx?sm=4mp8tw3FIHSTIkwKJpecUQ\\_3d\\_3d](https://surveymonkey.com/s.aspx?sm=4mp8tw3FIHSTIkwKJpecUQ_3d_3d)

Thank you in advance for your participation.

Carlos Y. Kaduoka, MRAeS

PS: If you have additional questions, please email c.y.kaduoka@cranfield.ac.uk

Please note: If you do not wish to receive further emails from us, please click the link below, and you will be automatically removed from our mailing list.

[https://surveymonkey.com/optout.aspx?sm=4mp8tw3FIHSTIkwKJpecUQ\\_3d\\_3d](https://surveymonkey.com/optout.aspx?sm=4mp8tw3FIHSTIkwKJpecUQ_3d_3d)

### **E.3 Collector: PhD Thesis Survey – sent on 02 September 2014**

FROM: c.y.kaduoka@cranfield.ac.uk via surveymonkey.com

DATE: Tuesday, September 02, 2014 10:46 AM

SENT TO: 1,380 recipients

SUBJECT: Airport performance and IT: a relationship

Dear [FirstName] [LastName],

I would appreciate your help with my doctorate research by spending a few minutes to respond to this survey. As the subject line indicates, this academic research aims to provide an insight into airport performance and IT.

Your response will be aggregated for analyses and the consolidated results will be used as part of my thesis submission. To respond to the survey does not require you to be knowledgeable or an IT expert.

All information obtained as part of the research shall be regarded and treated as confidential.

If you wish to receive a copy of the aggregated results please email me.

To start the survey, click the link below:

[https://surveymonkey.com/s.aspx?sm=4mp8tw3FIHSTIkwKJpecUQ\\_3d\\_3d](https://surveymonkey.com/s.aspx?sm=4mp8tw3FIHSTIkwKJpecUQ_3d_3d)

Thank you in advance for your participation.

Carlos Y. Kaduoka, MRAeS

PS: If you have additional questions, please email c.y.kaduoka@cranfield.ac.uk

Please note: If you do not wish to receive further emails from us, please click the link below, and you will be automatically removed from our mailing list.

[https://surveymonkey.com/optout.aspx?sm=4mp8tw3FIHSTIkwKJpecUQ\\_3d\\_3d](https://surveymonkey.com/optout.aspx?sm=4mp8tw3FIHSTIkwKJpecUQ_3d_3d)

## **E.4 Collector: PhD Thesis Survey – sent on 23 September 2014**

FROM: c.y.kaduoka@cranfield.ac.uk via surveymonkey.com

DATE: Tuesday, September 23, 2014 11:41 AM

SENT TO: 1,335 recipients

SUBJECT: The relationship between Airport Performance and Information Technology

Dear [FirstName] [LastName],

I would appreciate your help with my doctorate research by spending a few minutes to respond to this survey. As the subject line indicates, this academic research aims to provide an insight into airport performance and IT.

Your response will be aggregated for analyses and the consolidated results will be used as part of my thesis submission. To respond to the survey does not require you to be knowledgeable or an IT expert.

All information obtained as part of the research shall be regarded and treated as confidential.

If you wish to receive a copy of the aggregated results please email me.

To start the survey, click the link below:

[https://surveymonkey.com/s.aspx?sm=4mp8tw3FIHSTIkwKJpecUQ\\_3d\\_3d](https://surveymonkey.com/s.aspx?sm=4mp8tw3FIHSTIkwKJpecUQ_3d_3d)

Thank you in advance for your participation.

Carlos Y. Kaduoka, MRAeS

PS: If you have additional questions, please email c.y.kaduoka@cranfield.ac.uk

Please note: If you do not wish to receive further emails from us, please click the link below, and you will be automatically removed from our mailing list.

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## **E.5 Collector: Survey CK Additional Names – sent on 22 August 2014**

FROM: c.y.kaduoka@cranfield.ac.uk via surveymonkey.com

DATE: Friday, August 22, 2014 2:51 PM

SENT TO: 79 recipients

SUBJECT: Cranfield University: Doctorate thesis research: request for feedback

Dear [FirstName] [LastName],

I would like to invite you to participate in this academic research survey, as part of my doctorate research, aimed to provide an insight into airports and their views on IT. If you wish to receive a copy of the aggregated results please email me.

This survey will take approximately 5 minutes to complete, and your response will be aggregated for analyses and whose results will be used as part of my thesis submission. To respond to the survey does not require you to be knowledgeable or an IT expert.

All information obtained as part of the research shall be regarded and treated as confidential.

To start the survey, click the link below:

[https://surveymonkey.com/s.aspx?sm=c3HoCulbCvmPm\\_2fOVNUnZyw\\_3d\\_3d](https://surveymonkey.com/s.aspx?sm=c3HoCulbCvmPm_2fOVNUnZyw_3d_3d)

Thank you in advance for your participation.

Carlos Y. Kaduoka, MRAeS

PS: If you have additional questions, please email c.y.kaduoka@cranfield.ac.uk

Please note: If you do not wish to receive further emails from us, please click the link below, and you will be automatically removed from our mailing list.

[https://surveymonkey.com/optout.aspx?sm=c3HoCulbCvmPm\\_2fOVNUnZyw\\_3d\\_3d](https://surveymonkey.com/optout.aspx?sm=c3HoCulbCvmPm_2fOVNUnZyw_3d_3d)

## **E.6 Collector: Survey CK Additional Names – sent on 02 September 2014**

FROM: c.y.kaduoka@cranfield.ac.uk via surveymonkey.com

DATE: Tuesday, September 02, 2014 10:42 AM

SENT TO: 68 recipients

SUBJECT: Airport performance and IT: a relationship

Dear [FirstName] [LastName],

I would appreciate your help with my doctorate research by spending a few minutes to respond to this survey. As the subject line indicates, this academic research aims to provide an insight into airport performance and IT.

Your response will be aggregated for analyses and the consolidated results will be used as part of my thesis submission. To respond to the survey does not require you to be knowledgeable or an IT expert.

All information obtained as part of the research shall be regarded and treated as confidential.

If you wish to receive a copy of the aggregated results please email me.

To start the survey, click the link below:

[https://surveymonkey.com/s.aspx?sm=c3HoCulbCvmPm\\_2fOVNUnZyw\\_3d\\_3d](https://surveymonkey.com/s.aspx?sm=c3HoCulbCvmPm_2fOVNUnZyw_3d_3d)

Thank you in advance for your participation.

Carlos Y. Kaduoka, MRAeS

PS: If you have additional questions, please email c.y.kaduoka@cranfield.ac.uk

Please note: If you do not wish to receive further emails from us, please click the link below, and you will be automatically removed from our mailing list.

[https://surveymonkey.com/optout.aspx?sm=c3HoCulbCvmPm\\_2fOVNUnZyw\\_3d\\_3d](https://surveymonkey.com/optout.aspx?sm=c3HoCulbCvmPm_2fOVNUnZyw_3d_3d)

## **E.7 Collector: Survey CK Additional Names – sent on 23 September 2014**

FROM: c.y.kaduoka@cranfield.ac.uk via surveymonkey.com

DATE: Tuesday, September 23, 2014 11:52 AM

SENT TO: 62 recipients

SUBJECT: The relationship between Airport Performance and Information Technology

Dear [FirstName] [LastName],

I would appreciate your help with my doctorate research by spending a few minutes to respond to this survey. As the subject line indicates, this academic research aims to provide an insight into airport performance and IT.

Your response will be aggregated for analyses and the consolidated results will be used as part of my thesis submission. To respond to the survey does not require you to be knowledgeable or an IT expert.

All information obtained as part of the research shall be regarded and treated as confidential.

If you wish to receive a copy of the aggregated results please email me.

To start the survey, click the link below:

[https://surveymonkey.com/s.aspx?sm=c3HoCulbCvmPm\\_2fOVNUnZyw\\_3d\\_3d](https://surveymonkey.com/s.aspx?sm=c3HoCulbCvmPm_2fOVNUnZyw_3d_3d)

Thank you in advance for your participation.

Carlos Y. Kaduoka, MRAeS

PS: If you have additional questions, please email [c.y.kaduoka@cranfield.ac.uk](mailto:c.y.kaduoka@cranfield.ac.uk)

Please note: If you do not wish to receive further emails from us, please click the link below, and you will be automatically removed from our mailing list.

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## **E.8 Collector: Personal Invitation – sent on 22 August 2014**

FROM: c.y.kaduoka@cranfield.ac.uk via surveymonkey.com

DATE: Friday, August 22, 2014 4:01 PM

SENT TO: 10 recipients

SUBJECT: Cranfield University: Doctorate research - request for feedback

Dear [FirstName],

I am on the final stages of my research but still need additional responses to ensure that my sample is representative.

So I should be grateful if you could take a few minutes of your time (expected a maximum of 5 minutes) to respond to this academic research survey, aimed to provide an insight into airports and their views on IT.

Your response will be aggregated for analyses and the consolidated results will be used as part of my thesis submission. To respond to the survey does not require you to be knowledgeable or an IT expert.

All information obtained as part of the research shall be regarded and treated as confidential.

If you wish to receive a copy of the aggregated results please email me.

To start the survey, click the link below:

[https://surveymonkey.com/s.aspx?sm=c3HoCulbCvmPm\\_2fOVNUnZyw\\_3d\\_3d](https://surveymonkey.com/s.aspx?sm=c3HoCulbCvmPm_2fOVNUnZyw_3d_3d)

Thank you in advance for your participation.

Carlos Y. Kaduoka, MRAeS

PS: If you have additional questions, please email c.y.kaduoka@cranfield.ac.uk

Please note: If you do not wish to receive further emails from us, please click the link below, and you will be automatically removed from our mailing list.

[https://surveymonkey.com/optout.aspx?sm=c3HoCulbCvmPm\\_2fOVNUnZyw\\_3d\\_3d](https://surveymonkey.com/optout.aspx?sm=c3HoCulbCvmPm_2fOVNUnZyw_3d_3d)



## **E.9 Collector: Personal Invitation – sent on 02 September 2014**

FROM: c.y.kaduoka@cranfield.ac.uk via surveymonkey.com

DATE: Tuesday, September 02, 2014 10:32 AM

SENT TO: 8 recipients

SUBJECT: IT and Airport Performance

Dear [FirstName],

I would appreciate your help with my doctorate research by spending a few minutes to respond to this survey.

As the subject line indicates, this academic research aims to provide an insight into airport performance and IT.

Your response will be aggregated for analyses and the consolidated results will be used as part of my thesis submission. To respond to the survey does not require you to be knowledgeable or an IT expert.

All information obtained as part of the research shall be regarded and treated as confidential.

If you wish to receive a copy of the aggregated results please email me.

To start the survey, click the link below:

[https://surveymonkey.com/s.aspx?sm=c3HoCulbCvmPm\\_2fOVNUnZyw\\_3d\\_3d](https://surveymonkey.com/s.aspx?sm=c3HoCulbCvmPm_2fOVNUnZyw_3d_3d)

Thank you in advance for your participation.

Carlos Y. Kaduoka, MRAeS

PS: If you have additional questions, please email c.y.kaduoka@cranfield.ac.uk

Please note: If you do not wish to receive further emails from us, please click the link below, and you will be automatically removed from our mailing list.

[https://surveymonkey.com/optout.aspx?sm=c3HoCulbCvmPm\\_2fOVNUnZyw\\_3d\\_3d](https://surveymonkey.com/optout.aspx?sm=c3HoCulbCvmPm_2fOVNUnZyw_3d_3d)

## **E.10 Collector: PhD Final Push – sent on 22 October 2014**

FROM: c.y.kaduoka@cranfield.ac.uk via surveymonkey.com

DATE: Wednesday, October 22, 2014 6:18 PM

SENT TO: 1,265 recipients

SUBJECT: The relationship between Airport Performance and Technology - a PhD research

Dear [FirstName] [LastName],

I should be grateful for your help with my doctorate research by spending a few minutes to respond to this survey. As the subject line indicates, this academic research aims to provide an insight into airport performance and technology.

Your response will be aggregated for analyses and the consolidated results will be used as part of my thesis submission. To respond to the survey does not require you to be knowledgeable or an IT expert.

All information obtained as part of the research shall be regarded and treated as confidential.

If you wish to receive a copy of the aggregated results please email me.

To start the survey, click the link below:

[https://surveymonkey.com/s.aspx?sm=c3HoCulbCvmPm\\_2fOVNUnZyw\\_3d\\_3d](https://surveymonkey.com/s.aspx?sm=c3HoCulbCvmPm_2fOVNUnZyw_3d_3d)

Thank you in advance for your participation.

Carlos Y. Kaduoka, MRAeS

PS: If you have additional questions, please email c.y.kaduoka@cranfield.ac.uk

Please note: If you do not wish to receive further emails from us, please click the link below, and you will be automatically removed from our mailing list.

[https://surveymonkey.com/optout.aspx?sm=c3HoCulbCvmPm\\_2fOVNUnZyw\\_3d\\_3d](https://surveymonkey.com/optout.aspx?sm=c3HoCulbCvmPm_2fOVNUnZyw_3d_3d)

## **E.11 Collector: PhD Thesis: The Airport IT culture – sent on 10 July 2014**

FROM: c.y.kaduoka@cranfield.ac.uk via surveymonkey.com

DATE: Thursday, July 10, 2014 5:21 PM

SENT TO: 74 recipients

SUBJECT: Cranfield University: PhD thesis research - request for Additional feedback

Dear [FirstName] [LastName]

First of all, I would like to thank you for participating in the survey.

I have been notified that due to a glitch a page related to the IT culture of the airport was missing.

So I would hope you will kindly spend less than 5 minutes to answer 3 questions.

All information obtained as part of the research shall be regarded and treated as confidential.

To start the survey, click the link below:

[https://surveymonkey.com/s.aspx?sm=vHfgR7pXwFWa11GPUgfRdw\\_3d\\_3d](https://surveymonkey.com/s.aspx?sm=vHfgR7pXwFWa11GPUgfRdw_3d_3d)

Thank you in advance for your participation.

Carlos Y. Kaduoka, MRAeS

PS: If you have additional questions, please email [c.y.kaduoka@cranfield.ac.uk](mailto:c.y.kaduoka@cranfield.ac.uk)

Please note: If you do not wish to receive further emails from us, please click the link below, and you will be automatically removed from our mailing list.

[https://surveymonkey.com/optout.aspx?sm=c3HoCulbCvmPm\\_2fOVNUnZyw\\_3d\\_3d](https://surveymonkey.com/optout.aspx?sm=c3HoCulbCvmPm_2fOVNUnZyw_3d_3d)

## **E.12 Collector: PhD Thesis: The Airport IT culture – sent on 22 August 2014**

FROM: c.y.kaduoka@cranfield.ac.uk via surveymonkey.com

DATE: Friday, August 22, 2014 4:19 PM

SENT TO: 43 recipients

SUBJECT: Reminder: Cranfield University: PhD thesis research - request for additional feedback

Dear [FirstName][LastName],

I am on the final stages of my research but still need additional responses to ensure that my sample is representative.

So I should be grateful if you could take a few minutes of your time to 3 questions, which were missing from the already answered survey due to a technical glitch.

Your response will be aggregated for analyses and the consolidated results will be used as part of my thesis submission. To respond to the survey does not require you to be knowledgeable or an IT expert.

All information obtained as part of the research shall be regarded and treated as confidential.

If you wish to receive a copy of the aggregated results please email me.

To start the survey, click the link below:

[https://surveymonkey.com/s.aspx?sm=vHfgR7pXwFWa11GPUgfRdw\\_3d\\_3d](https://surveymonkey.com/s.aspx?sm=vHfgR7pXwFWa11GPUgfRdw_3d_3d)

Thank you in advance for your participation.

Carlos Y. Kaduoka, MRAeS

PS: If you have additional questions, please email c.y.kaduoka@cranfield.ac.uk

Please note: If you do not wish to receive further emails from us, please click the link below, and you will be automatically removed from our mailing list.

[https://surveymonkey.com/optout.aspx?sm=c3HoCulbCvmPm\\_2fOVNUnZyw\\_3d\\_3d](https://surveymonkey.com/optout.aspx?sm=c3HoCulbCvmPm_2fOVNUnZyw_3d_3d)

**E.13 Collector: PhD Thesis: The Airport IT culture – sent on 02 September 2014**

FROM: c.y.kaduoka@cranfield.ac.uk via surveymonkey.com

DATE: Tuesday, September 02, 2014 5:12 PM

SENT TO: 35 recipients

SUBJECT: Airport Performance and IT: understanding the airport IT culture

Dear [FirstName] [LastName],

I would appreciate your help with my doctorate research by spending a few minutes to respond to 3 questions that due to a glitch were missing from the original survey. As the subject line indicates, this academic research aims to provide an insight into airport performance and IT.

Your response will be aggregated for analyses and the consolidated results will be used as part of my thesis submission. To respond to the survey does not require you to be knowledgeable or an IT expert.

All information obtained as part of the research shall be regarded and treated as confidential.

If you wish to receive a copy of the aggregated results please email me.

To start the survey, click the link below:

[https://surveymonkey.com/s.aspx?sm=vHfgR7pXwFWa11GPUgfRdw\\_3d\\_3d](https://surveymonkey.com/s.aspx?sm=vHfgR7pXwFWa11GPUgfRdw_3d_3d)

Thank you in advance for your participation.

Carlos Y. Kaduoka, MRAeS

PS: If you have additional questions, please email c.y.kaduoka@cranfield.ac.uk

Please note: If you do not wish to receive further emails from us, please click the link below, and you will be automatically removed from our mailing list.

[https://surveymonkey.com/optout.aspx?sm=c3HoCulbCvmPm\\_2fOVNUnZyw\\_3d\\_3d](https://surveymonkey.com/optout.aspx?sm=c3HoCulbCvmPm_2fOVNUnZyw_3d_3d)

## Appendix F – Revenue estimation

North American Airports (USA and Canada)						
	YUL	BZN	DTW	LAX	YYZ	DFW
Rev US\$	436,000,000	7,020,641	319,000,000.0 0	902,000,000.0 0	1,139,000,000	540,000,000
Mean	222,754,766	14,161,560	520,489,157.5 6	1,028,130,279	563,591,978.2 6	946,336,671.6 1
Size	252,026,832	14,020,686	718,156,362.6 3	1,238,303,377	777,628,427.4 8	1,139,789,305. 67
	YUL	BZN	DTW	LAX	YYZ	DFW
Mean	-49%	102%	63%	14%	-51%	75%
Size	-42%	100%	125%	37%	-32%	111%
European Airports (UK, Austria, Switzerland, Belgium, Malta, and Slovakia)						
	VIE	ABZ	GVA	BRU	MLA	BTS
Rev US\$	784,000,000	74,470,130	390,000,000	540,000,000	83,825,397	41,754,386
Mean	610,043,985	92,712,237	380,415,154	517,894,996	100,872,458	38,954,027
Size	489,387,654	54,195,272	252,032,823	415,464,169	58,965,358	22,770,716
	VIE	ABZ	GVA	BRU	MLA	BTS
Mean	-22%	24%	-3%	-4%	20%	-7%
Size	-38%	-27%	-35%	-23%	-30%	-45%
Asian Airports (Australia, Indonesia, Singapore, Taiwan and Thailand)						
	MEL	SYD	DPS	SIN	TPE	BKK
Rev US\$	611,000,000	1,079,000,000	373,000,000	1,540,000,000	458,000,000	980,000,000
Mean	576,152,793	725,097,952	277,741,693	1,002,803,477	545,409,466	1,038,472,946
Size	654,989,697	824,315,518	258,910,895	995,140,063	620,039,658	1,030,536,947
	MEL	SYD	DPS	SIN	TPE	BKK
Mean	-6%	-33%	-26%	-34.9%	19%	6%
Size	7%	-24%	-31%	-35.4%	35%	5%

Latin America and Caribbean (Argentina, Brazil, Barbados and Guadeloupe)						
	EZE	GRU	GIG	PTP	BGI	
Rev US\$	511,000,000	2,228,000,000	213,227,513.2	51,336,553.4	37,579,891	
Mean	127,635,901.4	476,069,594.9	256,021,438.0	28,667,829.6	28,327,425	
Size	162,194,673.8	737,771,261.7	393,942,318.6	32,142,791.9	31,761,125	
	EZE	GRU	GIG	PTP	BGI	
Mean	-75%	-79%	20%	-44%	-25%	
Size	-68%	-67%	85%	-37%	-15%	
Middle East and Africa (Israel and South Africa)						
	TLV	JNB				
Rev US\$	622,950,820	779,000,000				
Mean	317,032,071	321,632,270				
Size	239,886,883	416,351,476				
	TLV	JNB				
Mean	-49%	-59%				
Size	-61%	-47%				

## Appendix G – Ownership models

Airport (2015)	Ownership structure	Classification
Aberdeen Airport	100% Heathrow	Private
Abu Dhabi Airports Company	100% Government	Public
Adelaide International Airport Limited	UniSuper Ltd 37.40 %, Motor Traders Association of Australia Superannuat 27.50 %, Local Government Superannuation Board 16.10 %, Others 19.00 %	Mixed (Private majority)
Aerodrom Maribor D.O.O	100% owned by Slovenian bank: Delavska Hranilnica (PLC)	Public
Aeroport de Quebec Inc.	Aeroport Quebec Inc is responsible for operations, management and development of the airport	Private
Aeroport International Leopold Sedar Senghor	Public	Public
Aeroporto di Genova SpA	Public: 15% Rome Airport, 60% Port Authority, 25% Local Government	Public
Aeroporto Friuli-Venezia Giulia SpA	100% Local Government	Public
Aeroporto Guglielmo Marconi Di Bologna S.P.A	50.55% Chamber of Commerce, 16.75% Municipality, 10% Provincial Authority, 8.80% Regional Authority, 7.21% Aeroporti Holding, 6.69% Others	Mixed (Public majority)
Aeroports de Montreal	Nor-for-profit corporation without share capital responsible for management, operations and development of the airport	Private
Aeropuertos Argentina 2000	Corporacion America 45.9%, Estado Nacional 15%, SEA 8.5%, Corp America 29.75%, Riva 0.85%	Mixed (Private majority)
AEROSTAR Airport Holdings	Public-Private Partnership (mixed ownership) of San Juan Airport	Public (Lease/Concession)
Airport Authority Hong Kong	Corporatised	Corporatised
Airport Bratislava Letisko M.R. Stefanika	Public	Public
Airport International Group (AIG)	Public but under concession	Public (Lease/Concession)
Airport Kosice	Mixed: 66% Vienna Airport, 34% Slovak Republic	Mixed (Private majority)
Airport Ljubljana	Mixed: 51% Republic, 28% Others, 7% Pension Fund, 7% Slovenia Restitution Fund, Maksima 8%	Mixed (Public majority)
Airports Authority of India	Public	Public
Airports Company South Africa	Corporatised: owned by the government but run by a legally and financially autonomous company	Corporatised
Airports Corporation of Vietnam	State-owned company	Corporatised
Airports of Mauritius Co Ltd.	100% Owned by the Government	Public
Airports of Thailand Public Co. Ltd.	Corporatised	Corporatised



Airport (2015)	Ownership structure	Classification
Alarko ( Astana Airport Kazakhstan )	Public	Public
Amsterdam Airport Schiphol	N.V. Luchthaven Schiphol (Schiphol Group) is a public limited liability company with a full two-tier board regime. The Dutch government, the Municipality of Amsterdam, Aéroports de Paris and the Municipality of Rotterdam are joint shareholders. The governance structure is based on Book 2 of the Dutch Civil Code, the company's Articles of Association and various internal regulations.	Corporatised
Asmara International Airport	Public	Public
Athens International Airport S.A.	Mixed: Government 55%, Hochtief 44.87%, Athen-Spata 0.12%	Mixed (Public majority)
Atm Dalaman Havalimani Yapim Ve Isletme A.S.	Private: ATM Construction and Management consortium *YDA and Turkuaz)	Private
Auckland International Airport Ltd	Others 53%, City Council 12.76%, Commonwealth Bank 15.90%, UBS 8.70%, Manukau City Council 10.01%	Mixed (Private majority)
Australia Pacific Airports (Melbourne)	AMP 41%, Deutsche Bank 26.00%, BAA 20.00%, Hastings Funds 13.00%	Private
Autoridad Aeroportuaria de Guayaquil	Public but managed by TAGSA a private company - 50years lease	Public (Lease/Concession)
Bahrain Airport Company	Public	Public
Bangalore International Airport Ltd	Siemens 40%, Zurich 17%, Larsen & Toubro 17%, KSIIDC 13%, AAI 13%	Mixed (Private majority)
Bangor (BGR) International Airport	Regional/Local Government 100%	Public
Barkley Regional Airport	Public	Public
Bermuda International Airport L.F. Wade International Airport	Ministry of Transport 100%	Public
Billund Airport Authority	Municipalities: Vejle 34.3%, Kolding 23.9%, Billund 15%, Horsens 10.7%, totalling 100%	Public
Birmingham Airport	Ontario Teachers Fund 48.25%, Seven West Midlands District Councils 49.00%, Employee Share Trust 2.75%	Mixed (Private majority)
Bozeman Yellowstone (BZN) International Airport Gallatin Airport Authority	Regional/Local Government 100%	Public
Brisbane Airport Corporation Limited	17% Colonial First State Global Asset Management and related managed funds, 4% Commonwealth Bank Group Super, 13.8% IFM Infrastructure Funds, 4.9% Motor Trades Association of Australia, 15.1% National Asset Management Limited as Trustee for the Brisbane Airport Trust, 25% QIC Limited, 18.7%	Private

Airport (2015)	Ownership structure	Classification
	Amsterdam Airport Schiphol, 1.5 % Sunsuper Pty Limited	
Bristol Airport	Ontario Teachers Fund	Private
Brussels Airport Company N.V./S.A.	Map 75%, State of Belung 25%	Mixed (Private majority)
Cagliari Airport	Chamber of Commerce 94.353% and small shareholders	Public
Cairns Airport	IIF Mackay 50%, The Infrastructure Fund 20%, Perron 5%, Auckland Intl Airport 25%	Private
Cambodia Airports	Concession with Vinci 70%, Muibbah Masteron Cambodia 30%	Public (Lease/Concession)
Changi Airport Group (S) Pte Ltd	Corporatised	Corporatised
Chicago Midway (MDW) International Airport	City of Chicago	Public
Christchurch International Airport	Regional/Local Government 75%, Federal 25%	Public
City of Atlanta Department of Aviation	City of Atlanta	Public
City of Killeen - Killeen-Fort Hood Regional Airport	Public	Public
Curacao Airport Partners N.V.	Concession owned by Aport and Janssen de Jong	Public (Lease/Concession)
Dallas Fort Worth International Airport	City of Dallas and City of Fort Worth	Public
Delhi International Airport (P) Ltd	GMR 60.10%, Fraport 10%, IDF 3.90%, AAI 26%	Mixed (Public majority)
Doha International Airport	Qatar Civil Aviation Authority	Public
Dubai Airport Company (DAC)	Government of Dubai	Public
Dublin Airport Authority Plc	Federal Government 100%	Public
EAC - Egyptian Airports Company	Public	Public
East Bohemian Airport	City of Pardubice	Public
Ethiopian Airports Enterprise	Public	Public
Exeter Airport	Bought by the Patriot Aerospace division of Rigby Group	Private
Flughafen Berlin Brandenburg GmbH	Regional/Local Government 74%, Federal 26%	Public
Flughafen Bremen GmbH	Regional/Local Government 100%	Public
Flughafen Koeln/Bonn GmbH	Regional/Local Government 39%, Federal 61%	Public
Flughafen Munich GmbH	Bavarian Government 51%, Federal 26%, Regional 23%	Public
Flughafen Nuernberg GmbH	Federal 50%, Local 50%	Mixed

Airport (2015)	Ownership structure	Classification
Flughafen Stuttgart GmbH	Federal 50%, Local 50%	Mixed
Flughafen Wien Aktiengesellschaft	Province 20%, City of Vienna 20%, Private Investors 49%, Schiphol Airport 1%, Employees 10%	Mixed (Private majority)
Flughafen Zurich AG	Canton of Zurich 47%, City of Zurich 5%, Free float 48%	Mixed (Public majority)
Fraport AG Frankfurt Airport Services Worldwide	State of Hesse 32%, Federal 18.30%, City of Frankfurt 20.40%, Free Float 29.30%	Mixed (Public majority)
Fujairah International Airport	Public	Public
Galeao International Airport - GIG	Concession with mixed ownership (Odbrecht, Changi = 51%), Infraero 49%	Public (Lease/Concession)
Oslo Gardermoen Airport	State Owned Avinor 100% - Public Corporation	Corporatised
Gatwick Airport Ltd	Owned and managed by Global Infrastructure Partners (GIP) and others	Private
Geneva International Airport	Regional/Local Government 100%	Public
Ghana Airports Company Limited	Public	Public
Glasgow	Owned and Operated by AGS Airports	Private
GMR Hyderabad International Airport Limited	GMR63%, AAI 13%, Andhra Pradesh 13%, MAHB 11%	Mixed (Private majority)
Grantley Adams International Airport	Government of Barbados 100%	Public
Greater Orlando Airport Authority	Regional/Local Government 100%	Public
Greater Toronto Airports Authority	GTAA responsible for management, operations and development of the Toronto Airport	Private
GRU Sao Paulo International Airport	Concession with mixed ownership (Invepar, ACSA = 51%), Infraero 49%	Public (Lease/Concession)
Guandong Airport Management Corporation	Provincial Government	Public
Hartsfield-Jackson Atlanta (ATL) International Airport	City of Atlanta	Public
Heathrow Airport	Private	Private
Houston Airport System	City of Houston	Public
International Airport Sarajevo	Public	Public
Israel Airport Authority	Government	Public
Jonkoping Airport	Government	Public
Jordan Airports Company PSC	Public but under concession	Public (Lease/Concession)
JSC Sochi International Airport	Private owned by the Basic Element Group	Private
JSC Tolmachevo airport	Federal 51%, Novaport 38%	Mixed (Public majority)
Incheon International Airport Corporation	Government owned - operated by IIAC	Public

Airport (2015)	Ownership structure	Classification
Karlovy Vary International Airport	Regional/Local Government 100%	Public
Kelowna International Airport	Owner Transport of Canada, operated by City of Kelowna	Public
Kilimanjaro International Airport	Government 24%, South African Infra Fund 30%, Mott MacDonald 44.4%, Inter-Consult 4.60%	Mixed (Private majority)
King Khaled International Airport	Saudi General Authority of Civil Aviation (GACA)	Public
Kobenhavns Lufthaven A/S (Copenhagen Airports)	CAD 57.7%, Danish Sate 39.2%, Foreign Investors 1.8%, Danish Investors 1.3%	Mixed (Private majority)
Koltsovo Airport	Federal 61%, Private 39%	Mixed (Public majority)
Korea Airports Corporation	Government - Korea Airports Corporation	Public
Letiste Brno	Regional/Local Government 100%	Public
Liege Airport S.A.	Wallon Regional airport 25%, ADPm 25%, TEB 50%	Mixed (Private majority)
Limak Kosovo International Airport	Public Private Partnership (Limak and Lyon Airport)	Public (Lease/Concession)
Little Rock Municipal Airport Commission	Public	Public
LLC Airport Yemelyanovo	Public	Public
Lome Airports	Federal 60%, Regional 35%, Private 5%	Mixed (Public majority)
Los Angeles World Airports	Public	Public
Maastricht Aachen Airport	Federal 30%, Omniport 70%	Mixed (Private majority)
Malaysia Airports Holdings Berhad	Corporatized and listed Khazanah Nasional 40.22%	Corporatized
Maldives Airports Company Ltd	MACL 100% Owned limited liability company to manage	Corporatized
Malta International Airport P.L.C.	Federal 20%, Malta Consortium 40%, Private 30%, VIE Airport 10%	Mixed (Private majority)
Manchester Airport Plc	Manchester City 35.5%, IFM 35.5%, Manchester Council 29%	Mixed (Public majority)
McCarran (LAS) International Airport	Public	Public
Miami-Dade County	Public	Public
Minna Airport	Public	Public
Mostar Airport	City of Mostar 88%, Zagreb Airport 12%	Public
Mumbai International Airport Pvt. Ltd	GVK 76%, AAI 26%	Mixed (Private majority)
National Airports Corporation Ltd.	Wholly owned by the Government of Zambia	Public
Newcastle International Airport Ltd	Local Authority 51%, AMP Capital 49% (PPP)	Mixed (Public majority)
Northern Capital Gateway	Consortium Fraport and Russian VTB Capital Bank (PPP)	Public (Lease/Concession)
Northern Territory Airports Pty Ltd	Palised Investments 22.6%, IFM Investors 77.4%	Private

Airport (2015)	Ownership structure	Classification
OJSC Mineralnye Vody International airport	Public	Public
Oman Airports Management Company (Oamc)	Public	Public
Osijek Airport	Public	Public
Ottawa Macdonald-Cartier Intl. Airport Authority	Authority has responsibility to manage and operate the airport	Private
Perth Airport	Private Investor (Westralia Airports Corporation)	Private
Philadelphia (PHL) International Airport	Public	Public
Pioneer Aerodrome Services Co.	Government owned - operated by Pioneer (Lease)	Public
Pointe-a-Pitre International Airport	Public	Public
Polish Airports State Enterprise	Public	Public
Port Lotniczy Poznan-Lawica Sp zoo	Public	Public
Port Lotniczy Rzeszow-Jasionka	Public	Public
Prestwick Airport	100% Scottish Government	Public
PT (Persero) Angkasa Pura I	Public - State Enterprise	Corporatised
Red Deer Regional Airports Authority	Managed and Operated by the county	Public
Regional Airport Prerov	Public	Public
Salerno Airport	Public	Public
Salt Lake City Airport Authority	Public	Public
San Antonio International Airport - The City of San Antonio	Public	Public
Sarasota Manatee Airport Authority	Public	Public
Skopje Alexander the Great Airport	Concession with TAV	Public (Lease/Concession)
Sofia Airport Ead	Public	Public
Southampton Airport	Owned by AGS Airports Limited	Private
Split Airport	Federal 55%, Regional/Local 45%	Public
Sudan Civil Aviation Authority	Public	Public
Sunshine Coast Airport	100% Sunshine Coast Regional Council	Public
Swedavia AB	Nationally owned company	Corporatised
Sydney Airports Corporation Limited	100% Private	Private
Tampa International Airport	Public	Public
Taoyuan International Airport Corporation Ltd.	Public	Public

Airport (2015)	Ownership structure	Classification
TAV Airports Holding Co.	Operated by TAV Airports	Public (Lease/Concession)
The John Paul II International Airport Krakow - Balice Ltd	76% State Owned, 22.73% Province, Commune 1.08%	Public
Thunder Bay International Airport	Government handed over to TBI Airport Authority in 1997 - not for profit organisation	Private
Tibah Airports Operation Limited	PPP with TAV for 25 years	Public (Lease/Concession)
Tonga Airports Limited	Public Enterprise owned by the Government of Tonga	Private
Tribhuvan International Airport	Public	Public
Vancouver Airport Authority	Not-for-profit organisation reinvests all earnings in airport development and improvements	Private
Detroit International Airport	Public	Public
Winnipeg Airports Authority	Non-share capital corporation that operates, manages, and invests.	Private
Zanzibar Airport	Established as Airport Authority in 2011	Public

## Appendix H – List of variables

Label	Variable	Measure
Size	PAX	Scale
Airport Performance	REV_MVT	Scale
Ownership	Ownership	Nominal
There is intense competition from other airports.	Q2_competition	Scale
Skilled technical and operational resources are an important element to a high performance airport.	Q3_skills	Scale
Outsourcing is one way to improve airport performance.	Q3_outsourcing	Scale
Outsourcing is currently used for most tasks and processes.	Q3_using_outcng	Scale
Strategic role - plays an active role in defining the airport's strategic goals.	Q5_strategic	Scale
Operational role - plays an important role to improve operational efficiency of the airport.	Q5_operational	Scale
ICT Custodian - is responsible for all IT-related matters of the airport.	Q5_custodian	Scale
Transformational role - plays an important role to change the airport processes through deployment of technology.	Q5_transform	Scale
ICT plays a mission critical role.	Q6_critical	Scale
ICT is key to the airport's growth.	Q6_growth	Scale
ICT is deployed to enhance the airport's products and services.	Q6_enhance	Scale
ICT addresses the airport's needs for automation and technology.	Q6_automation	Scale
ICT has a positive contribution to the performance of the airport.	Q6_performance	Scale
ICT enables the airport to do things differently and to become more competitive.	Q7_differential	Scale

Label	Variable	Measure
ICT helps to reduce costs.	Q7_costs	Scale
ICT is deployed to differentiate the airport's products and services.	Q7_products	Scale
ICT brings innovation and encourages innovations.	Q7_innovation	Scale
ICT such as Business Intelligence technologies improve decision-making and long-term planning.	Q7_BI	Scale
ACI Airport Service Quality surveys (ACI ASQ).	Q8_ASQ	Scale
Traditional Airport Performance Indicators, e.g. Work Load Units (WLU), Air Transport Movements, Total Passengers Per Movement, Total Revenue per WLU, etc.	Q8_Trad	Scale
Global Airport Benchmarking by ATRS (Air Transport Research Society).	Q8_ATRS	Scale
Financial Indicators, e.g. ROI, ROIC, EBITDA, etc.	Q8_Ratios	Scale
Operational Indicators, e.g., Queuing Time, Operational Service Level Agreements (SLA), etc.	Q8_Ops_KPI	Scale
Airport Benchmarking methodologies such as Data Envelopment Analysis, etc.	Q8_Bench	Scale
SKYTRAX Airport Ranking	Q8_Skytrax	Scale
Please specify other performance measures not included above.	Q8_others	Nominal
Do you participate in the ACI ASQ Survey?	Q9_ACIASQ	Nominal
Does your airport use the ACI ASQ Service Dimensions to improve airport performance?	Q10_ASQ_dimen	Nominal
Overall passenger satisfaction.	Q11_pax	Scale
Check-in.	Q11_ckin	Scale
Security.	Q11_security	Scale
Finding your way through the airport.	Q11_wayfinding	Scale



Label	Variable	Measure
Airport Facilities.	Q11_facilities	Scale
Access.	Q11_access	Scale
Arrival.	Q11_arrival	Scale
Airport Environment.	Q11_environ	Scale
Shared check-in infrastructure systems (CUTE and CUSS).	Q12_cute	Scale
Resource Management Systems (RMS).	Q12_rms	Scale
Airport Operational Database (AODB).	Q12_aodb	Scale
Flight Information Display Systems.	Q12_fids	Scale
Automated Baggage Handling and Reconciliation System.	Q12_bag	Scale
Airport Collaborative Decision Making (A-CDM).	Q12_acdm	Scale
How important is the investment in IT to improve airport performance?	Q13_IT_invest	Scale
Passenger/Baggage processing and related services.	Q14_pax_bag	Scale
Airport operations (management of resources, schedules).	Q14_ops	Scale
Airport Security.	Q14_security	Scale
Environment initiatives (reduction in carbon footprint)	Q14_environ	Scale
Business Intelligence (big data, Customer Relationship Management, A-CDM)	Q14_BI	Scale
Business support (HR, Finance, Marketing)	Q14_biz_func	Scale
Commercial (Point of sales applications, car parking, tenancy management).	Q14_commercial	Scale
My airport uses SLA as an important tool to measure airport performance.	Q15_sla	Scale
My airport uses SLA to manage Passenger processing time.	Q15_sla_pax	Scale
My airport uses SLA to manage Baggage processing time.	Q15_sla_bag	Scale

Label	Variable	Measure
My airport uses SLA to manage Aircraft processing time.	Q15_sla_acft	Scale
My airport uses Service Level Agreements as important tool to measure airport performance.	Q16_sla_tool	Nominal
My airport uses SLA to manage Passenger processing time.	Q17_sla_pax_time	Scale
My airport uses SLA to manage Baggage processing time.	Q17_sla_bag_time	Scale
My airport uses SLA to manage Aircraft processing time.	Q17_sla_acft_time	Scale
SLA_Index	SLA_Index	Scale
Outsourcing_Index	Outsourcing_Index	Scale
Recoded RQ5_strategic	RQ5_strategic	Scale
Recoded RQ5_operational	RQ5_operational	Scale
Recoded RQ5_custodian	RQ5_custodian	Scale
Recoded RQ5_transform	RQ5_transform	Scale
Recoded RQ7_different	RQ7_different	Scale
Recoded RQ7_costs	RQ7_costs	Scale
Recoded RQ7_products	RQ7_products	Scale
Recoded RQ7_innovation	RQ7_innovation	Scale
Recoded RQ7_BI	RQ7_BI	Scale
REGR factor score of Q-5	FAC1_Q_5	Scale
REGR factor score of Q_6	FAC1_Q_6	Scale
REGR factor score of Q-7	FAC1_Q_7	Scale
Q_3_index	Q_3_index	Scale
Q_15_index	Q_15_index	Scale
Q_13_14_index	Q_13_14_index	Scale



## Appendix I – SITA Airport IT Trends from 2009 to 2015

This Appendix provides an overview of the different Airport IT Trends reports from 2009 to 2015. The Airport IT Trends survey is an annual survey that started in 2004, and is a partnership and collaborative effort by Airports Council International (ACI), Airline Business and SITA, aimed at tracking key technology trends within the airport industry, and providing insights into the industry’s IT investment and the airport industry’s technology strategies.

The Airport IT Trends surveys have changed and improved to reflect the introduction of new technology trends such as mobility, geolocation technologies (e.g. Bluetooth, Wi-Fi, and beacons<sup>30</sup>). Additional information such as the global value of IT investment has been incorporated in the reports since 2013. And from 2014 the investment drivers have been merged as investment priorities.

The following tables provides a summary of the Investment Drivers and Priorities.

Survey	Investment Drivers			
	Reduce cost of business operations	Improve customer service	Improve airport safety and security	Improve workforce productivity
2009	X	X	X	
2010	X	X	X	
2011	X	X	X	
2012	X	X		X
2013	X	X	X	

**Table 27 Summary of IT Investment Drivers reported in Airport IT Trends Survey from 2009 to 2013**

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<sup>30</sup> “The beacon devices are an indoor proximity system available in various shapes and sizes but can be as small as a USB stick or larger and more visible. They transmit a signal using Bluetooth Low Energy, or BLE for short – the signal contains a unique identifier for that beacon. When a BLE-enabled device, such as a smartphone, moves within range of the beacon’s signal it can trigger an action, such as displaying a contextually relevant message on the phone. Beacons make possible a new range of user interactions.” SITA (2014)

Survey	Investment Priorities					
	Passenger processing	Operations	Passenger Security	Airport Security	Passenger & Airport Security	Baggage Processing
2009	X	X	X			
2010	X	X		X		
2011	X	X				
2012	X	X			X	
2013	X	X			X	
2014	X	X			X	
2015	X	X				X

**Table 28 Summary of the IT Investment Priorities reported in Airport IT Trends Survey from 2009 to 2015**

## I.1 Airport IT Trends 2009

SITA Airport IT Trends 2009	
Respondents	106 respondents representing views of over 172 airports
IT spend as percentage of revenue	3.6%
Top 3 IT investment drivers	<ol style="list-style-type: none"> <li>1. Improve airport safety and security</li> <li>2. Improve customer service &amp; satisfaction</li> <li>3. Reducing costs</li> </ol>
Top 3 IT investment priorities	<ol style="list-style-type: none"> <li>1. Passenger processing &amp; services</li> <li>2. Passenger security</li> <li>3. Airport operations (managing schedules and flights)</li> </ol>
Strategic direction	<p>As result of cost management pressure, airports are likely to invest in applications that improve operational efficiency (e.g. Airport Resource Allocation systems).</p> <p>Self-service is considered to become the primary means for passenger processing.</p> <p>Use of web portals to sell directly to passengers.</p>

## I.2 Airport IT Trends 2010

SITA Airport IT Trends 2010	
Respondents	128 respondents representing views of over 220 airports
IT spend as percentage of revenue	4.19% compared to 3.5% in 2009
Top 3 IT investment drivers	<ol style="list-style-type: none"> <li>1. Reducing the costs of business operations</li> <li>2. Improving customer service</li> <li>3. Improving airport safety and security</li> </ol>
Top 3 IT investment priorities	<ol style="list-style-type: none"> <li>1. Airport security</li> <li>2. Passenger processing and related services</li> <li>3. Airport operations</li> </ol>
Strategic direction	<p>Despite the positive confidence in IT spending, the focus still remains on delivering business efficiency through technology.</p> <p>Self-service will continue to be the preferred passenger processing method for airports.</p> <p>Airport Collaborative Decision Making (A-CDM) is focus from an operation's perspective at it foster information sharing and collaboration between stakeholders.</p>

### I.3 Airport IT Trends 2011

SITA Airport IT Trends 2011	
Respondents	100 respondents representing views of over 198 airports
IT spend as percentage of revenue	4.3% compared to 4.19% in 2010
Top 3 IT investment drivers	<ol style="list-style-type: none"> <li>1. Improving customer service</li> <li>2. Improving airport safety and security</li> <li>3. Reducing the cost of business operations</li> </ol>
Top 3 IT investment priorities	<ol style="list-style-type: none"> <li>1. Passenger processing &amp; related services</li> <li>2. Airport operations</li> </ol>
Strategic direction	<p>Self-service will continue to be the preferred passenger processing method for airports, and key driver of customer service vision.</p> <p>Mobile services will be a vital element to self-service strategies (e.g. mobile check-in).</p> <p>Social networks will be key in delivering better customer service.</p> <p>Business Intelligence and A-CDM will improve airport performance.</p>

## I.4 Airport IT Trends 2012

SITA Airport IT Trends 2012	
Respondents	91 respondents representing views of over 173 airports
IT spend as percentage of revenue	4.90% compared to 4.3% in 2011
Top 3 IT investment drivers	<ol style="list-style-type: none"> <li>1. Improving passenger experience</li> <li>2. Reducing the cost of operations</li> <li>3. Improving workforce productivity</li> </ol>
Top 3 IT investment priorities	<ol style="list-style-type: none"> <li>1. Passenger processing &amp; related services</li> <li>2. Airport operations (e.g. managing schedules and flights)</li> <li>3. Passenger &amp; airport security</li> </ol>
Strategic direction	<p>Self-service will continue to be the preferred passenger processing method for airports, and key driver of customer service vision.</p> <p>Mobile applications will become an important communication channel between airport and passengers.</p> <p>Business Intelligence and A-CDM are considered areas that will bring operational efficiency and cost savings.</p> <p>Geolocation technology (e.g. Bluetooth and Wi-Fi) is one technology that will help airports to deal with passenger congestion.</p>



## I.5 Airport IT Trends 2013

SITA Airport IT Trends 2013	
Respondents	122 respondents representing views of over 255 airports
IT spend as percentage of revenue	4.41% vs. 4.9% in 2012, which represents a total IT spend of US\$ 6 billion for the airport industry.
Top 3 IT investment drivers	<ol style="list-style-type: none"> <li>1. Improving passenger experience</li> <li>2. Reducing the cost of operations</li> <li>3. Improving airport security</li> </ol>
Top 3 IT investment priorities	<ol style="list-style-type: none"> <li>3. Passenger processing &amp; related services</li> <li>4. Airport operations</li> <li>5. Passenger &amp; airport security</li> </ol>
Strategic direction	<p>Self-service is expected to be implemented by 98% of airports, and automated baggage drop to be provided by 80% of airports by 2016.</p> <p>Mobile applications and social media will be used to keep passengers informed.</p> <p>Business Intelligence is expected to be used to increase non-aeronautical revenues through better passenger profiling and analytics to determine trends and buying patterns.</p>

## I.6 Airport IT Trends 2014

SITA Airport IT Trends 2014	
Respondents	106 respondents representing views of over 200 airports
IT spend as percentage of revenue	5.82% vs. 4.41% in 2013, which represents a total IT spend of US\$ 6.8 billion for the airport industry.
Top 3 IT investment drivers and priorities have been combined	<ol style="list-style-type: none"> <li>1. Improving passenger processing</li> <li>2. Improving passenger-related airport security</li> <li>3. Improving operations</li> </ol>
Strategic direction	<p>Self-service is the number one priority for airports in terms of IT investment.</p> <p>Automated bag drop is expected to be implemented by over 70% airports by 2017.</p> <p>97% of passengers carry mobile devices when travelling, and 60% of airports are expected to provide mobile alerts for disruption by 2017.</p> <p>By 2017, 89% of airports are expected to have implemented Business Intelligence to analyse airport service quality data.</p>

## I.7 Airport IT Trends 2015

SITA Airport IT Trends 2015	
Respondents	106 respondents representing views of over 200 airports
IT spend as percentage of revenue	5.21% vs. 5.82% in 2014, which represents a total IT spend of US\$ 7.8 billion for the airport industry.
Top 3 IT investment drivers and priorities have been combined	<ol style="list-style-type: none"> <li>1. Improving passenger processing</li> <li>2. Improving operations</li> <li>3. Improving baggage processing</li> </ol>
Strategic direction	<p>Self-service kiosks are available in 9 out of 10 airports. And airports are gradually enhancing the functionalities of kiosks (e.g. printing bag tags).</p> <p>By 2018, airports are expected to make major investments to improve flow with deployment of sensors at security checkpoints.</p> <p>Also by 2018, 80% of airports will have implemented way-finding services.</p> <p>Airports plan to provide the following services via mobile apps: flight status notifications, and way-finding.</p> <p>Airports want to use BI tools to monitor passenger flow, and deploy staff and assets more effectively, including the ability to exploit aircraft movement data.</p>