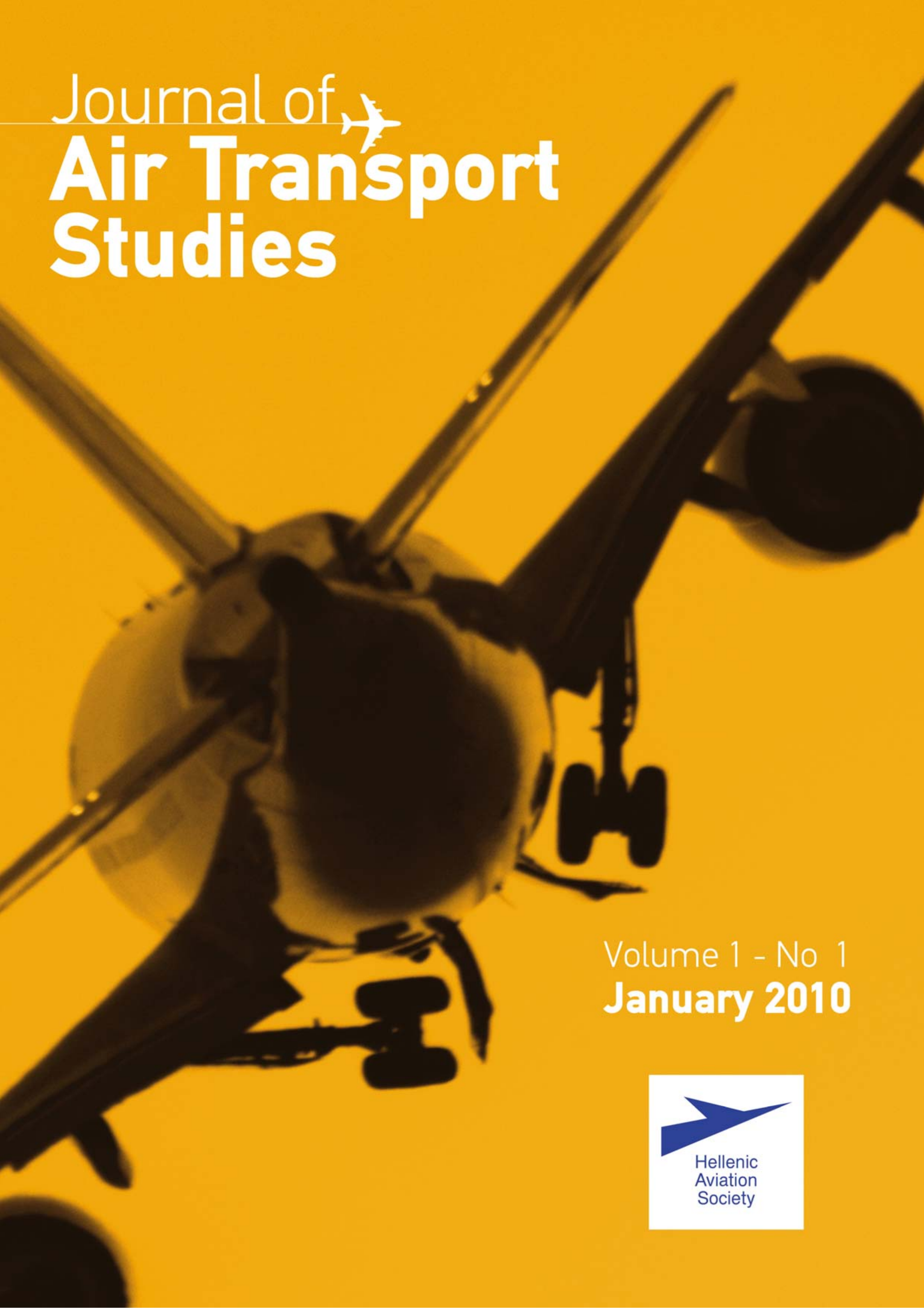
Journal of Air Transport Studies



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The *Journal of Air Transport Studies* (JATS – ISSN: 1791-6771) is a peer reviewed journal aiming at publishing high quality research related to air transport. JATS is interested in publishing papers primarily focusing on economics, geography, policymaking, management, marketing, operations, technology, logistics/supply chain management and modelling.

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JATS publishes the following categories of papers written in scholarly English: a) Full Research Papers, b) Conference Reports, c) Book Reviews, d) Industry Perspectives. Papers should be submitted electronically to a.papatheodorou@aegean.gr in MS-Word format ONLY using British spelling, single-column, 1.5 line spacing, Tahoma letters, font size 11. Section headings (and sub-headings) should be numbered and written in capital letters. Upon acceptance of a paper and before its publication, the corresponding author will be asked to sign the *Transfer of Copyright* form on behalf of all identified authors.

Full Research Papers should contain original research not previously published elsewhere. They should normally be between 4,000 and 7,000 words although shorter or lengthier articles could be considered for publication if they are of merit. The first page of the papers should contain the title and the authors' affiliations, contact details and brief vitae (of about 50 words). Regarding the following pages, papers should generally have the following structure: a) title, abstract (of about 150 words) and six keywords, b) introduction, c) literature review, d) theoretical and/or empirical contribution, e) summary and conclusions, f) acknowledgements, g) references and h) appendices. Tables, figures and illustrations should be included within the text (not at the end), bear a title and be numbered consecutively. Regarding the referencing style, standard academic format should be consistently followed. Examples are given below:

- Airbus (2003), *Global Market Forecasts 2003-2022*, Toulouse: Airbus.
- Fragoudaki, A., Keramianakis, M. and Jancovich, S. (2005) The Greek PSO Experience. *4th International Forum on Air Transport in Remoter Regions*. Stockholm, May 24-26.
- Forsyth P. (2002a), 'Privatization and Regulation of Australian and New Zealand Airports', *Journal of Air Transport Management*, 8, 19-28.
- Papatheodorou, A. (2008) The Impact of Civil Aviation Regimes on Leisure Market. In Graham, A., Papatheodorou, A. and Forsyth, P. (ed) *Aviation and Tourism: Implications for Leisure Travel*, Aldershot: Ashgate, 49-57.
- Skycontrol (2007) *easyJet welcomes European Commission's decision to limit PSO abuse in Italy*. 23rd April. Available from: http://www.skycontrol.net/airlines/easyjet-welcomes-european-commissions-decision-to-limit-pso-abuse-in-italy/ (accessed on 22/08/2008).

Conference Reports should be between 1,000 and 1,500 words. They should provide factual information (e.g. conference venue, details of the conference organizers), present the various programme sessions and summarize the key research findings.

Book Reviews should be between 1,000 and 1,500 words. They should provide factual information (e.g. book publisher, number of pages and ISBN, price on the publisher's website) and critically discuss the contents of a book mainly in terms of its strengths and weaknesses.

Industry Perspectives should be up to 1,000 words and provide a practitioner's point of view on contemporary developments in the air transport industry. Contributors should explicitly specify whether their views are espoused by their organization or not.

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punctuality of airlines becomes an increasingly relevant factor due to overfilled airspaces around mega hubs. The question which arises is what level of delay is still accepted by air passengers on business trips without creating dissatisfaction with the delayed airline and if the accepted delay changes with frequency of air travels by business passengers. The sample includes 2834 air travellers which were interviewed before they were entering their flights at gates or in business lounges. The results reveal that a delay up to 30 minutes is acceptable in air travel. The more a passenger travels by plane the lower is the level of acceptance towards delays or the more punctuality becomes a basic factor and a power factor.

The objective of the study is to understand the cooperation building process within Human-Human Interaction (HHI) during Collaborative Decision Making (CDM) in a distributed, multiple-objective decision making environment. It is based upon functional HHI analysis within typical CDM flight operation situations where the flight operation includes the inbound, turn-round, and outbound phases of the flight. A survey was undertaken which sought to identify aircraft pilots' perspective on cooperation with other operators during various flight situations. In this study, different situations are compared and characterized by: (1) a synchronous interaction mode, where all participating operators interact with each other at the same time, and (2) an asynchronous interaction mode, where the participating operators interact with each other at different times. Task and decision-making for all situations is distributed between operators. The aircraft pilot's perspective and their information requirements during these flight situations are used to identify critical information processing during CDM.

Mechanical locks and keys are conventional access control devices utilized for both flight training devices and training aircraft, but keys can be copied, locks can be bypassed, and in the case of electronic flight training devices, unqualified instructors or students may utilize the equipment, possibly causing the equipment to fail. The faculty in the Aviation Technology Department at Purdue University performed this study to determine if biometric usage is a feasible and secure method in operating a flight training device and eventually securing an actual aircraft versus the older lock and key method. A Finger-vein biometric reader was installed onto a Frasca Advanced Aviation Training Device (AATD) and the software was installed such that identification had to be made prior to the program being able to initialize. The data collected from the survey includes information such as user interface issues and conditions which affect the failure reads such the placement of the flight instructor's finger on the biometric device.

Editorial

This inaugurating issue of the *Journal of Air Transport Studies* includes five carefully selected papers covering various topics. **O'Connell and Williams** review the process of aviation liberalisation and its impact on the Middle East. The proposed multilateral regional air transport agreement closely mirrors the EU's Third Liberalization Package, which fully opened the aviation market among its Member States. A particularly interesting finding of the paper is that low-cost carriers are circumnavigating the regulatory obstacles and manage to gain a foothold in the marketplace of the Middle East.

In another paper, **Vogel and Graham** propose a driver-based approach to airport valuation. By analysing a sample of eight publicly quoted European airports, the authors find that the conventional valuation approach is prone to overall stock market fluctuations, unfriendly takeover bids or corporate share buybacks. Therefore, the authors suggest that an alternative approach focusing on business-based key performance indicators should be incorporated into airport valuation as these reflect more accurately the financial position and true value of the airport.

The other three papers have one thing in common, namely, their use of the survey research method. **Wittmer and Laesser** look into business travellers' perception of time. Based on a large survey, the authors find that a delay of up to 30 minutes is acceptable in air travel. **Groppe, Bui and Pagliari** conduct a survey to identify the aircraft pilot's perspective when cooperating with other operators during various flight situations. The results reveal that inadequate information sharing is a root cause for process failure during flight operation. Finally, **Dillman, Hendricks, Petrelli and Elliott** survey 43 flight instructors and find that that installing a biometric reader onto a flight simulator is a feasible and secure method in operating a flight training device. The findings have important commercial implications which could result in replacing the current lock-and-key method on aircraft with biometric access.

May we take this opportunity to thank all our authors and referees for their support in publishing this first issue of our Journal. Enjoy reading!

Dr Andreas Papatheodorou, Editor-in-Chief

Dr Kostas Iatrou, Associate Editor

Dr Zheng Lei, Assistant Editor

Air Transport Development in the Middle East: A Review of the Process of Liberalisation and its Impact

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ABSTRACT

The air transport market in the Middle East is undergoing a rapid transformation as passenger traffic is beginning to surge through the area. This paper examines the impact that deregulation is having on the region, including the growth of low cost carriers. It establishes that the region is working towards a pan-regional agreement on liberalisation under the leadership of the Arab Civil Aviation Commission.

KEYWORDS: Middle East, Arab Air Carriers Organization, Liberalisation, Pan-regional agreement on liberalisation, Arab Civil Aviation Commission, Low Cost Carriers.

1. INTRODUCTION

According to the World Tourism Organisation, the Middle East is comprised of Bahrain, Egypt, Iraq, Jordan, Kuwait, Lebanon, Libya, Oman, Palestine, Qatar, Saudi Arabia, Syria, the UAE and Yemen, with Israel placed in the East Mediterranean Europe category (World Tourism Organisation, 2005). The collective population of these states was approximately 179 million in 2007, which constitutes just 3 per cent of the world's population (IMF, 2007). The six main countries that are classified as the engines of growth in the Middle East are Bahrain, Kuwait, Oman, Qatar, Saudi Arabia and the United Arab Emirates (UAE), and are collectively known as

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[b] Dr. George Williams was until September 2009 Reader in Airline Economics at Cranfield Uiversity. With an academic background in Transport Economics, he has extensive international lecturing and consultancy experiences and has written two books and over 50 papers and research reports all exploring the impact of deregulation on the airline industry.

the GCC (Gulf Cooperation Council) countries. There are 24 member airlines[c] associated with the Arab Air Carriers Organization (AACO) as the assembly encompasses all the Arab nations, stretching from the Persian Gulf right across Northern Africa to Morocco – a distance of some 6,450kms.

The Middle East has long been seen as a geo-economic and geo-political epicentre of the world because of its vast reserves of hydrocarbons, while at the same time the region has been in a near constant state of conflict, keeping it under the spotlight of international attention. However, over recent years, there has been a tectonic shift in the global air transport market primarily because of the rise of the Middle East carriers, and in particular Arabian Gulf based airlines, which are beginning to impact the global airline industry. IATA data for 2007 highlighted that the growth in Middle East Revenue Passenger Kilometre (RPK) had surged to 18.1% - more than twice that of Africa which recorded the second highest growth rate.

This paper provides a brief overview of the Middle East's air transport market. It then describes the regulatory transformation that is beginning to penetrate the region and how low cost carriers are circumnavigating the regulatory obstacles and gaining a foothold in the marketplace. The study concludes with an analysis of a pan-regional agreement on liberalisation of the Middle East and it is compared to the EU third package. This paper fills a void in the existing literature regarding the deregulation of the Middle East air transport market.

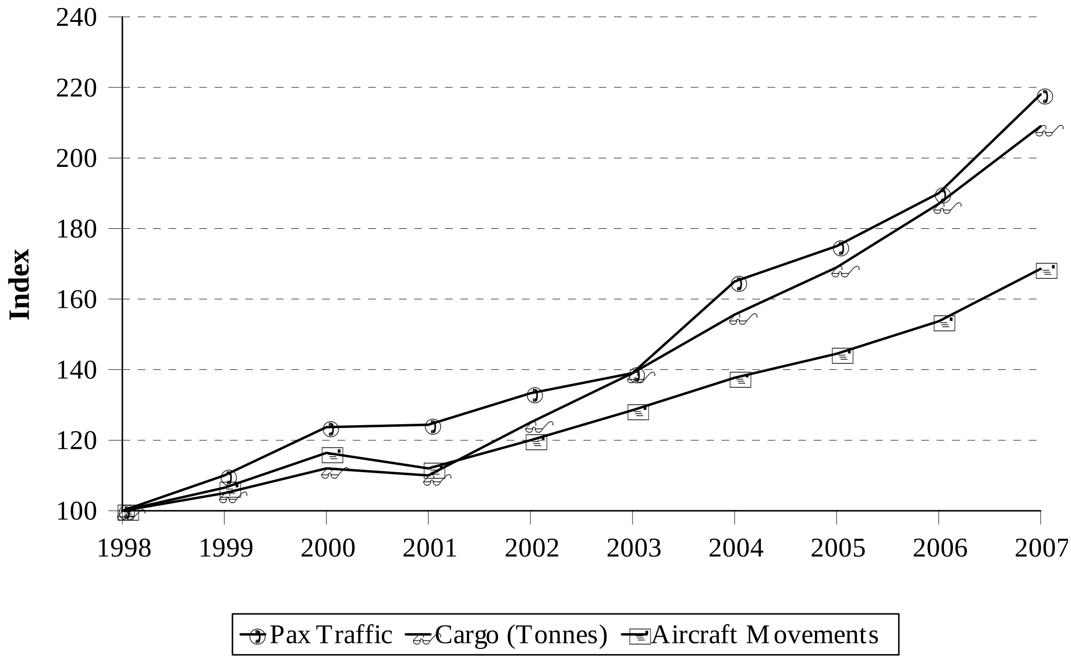
2. THE MIDDLE EAST'S RAPIDLY DEVELOPING AVIATION MARKET

ICAO (2007) calculated that the Middle East air transport market constitutes a mere 4.5% of the world market. However, its passenger traffic is heavily skewed towards international traffic of which it has a 7% share. There were approximately 79 million passengers transported by the 24 member airlines of the Arab Air Carriers Organisation (AACO) in 2007 (AACO, 2007). Non-AACO airlines transported an additional 46 million passengers to the Middle East and North Africa in 2007. Thus, the total air transport market stood at around 125 million passengers,

[c] The 24 members of the Arab Air Carriers Organization (AACO) are Afriqiyah, Air Algerie, Air Arabia, Air Cairo, Egyptair, Emirates, Etihad, Gulf Air, Iraqi Airways, Gulf Air, Kuwait Airways, Libyan Airlines, Middle East Airlines, Oman Air, Palestine Airlines, Qatar Airways, Royal Air Maroc, Royal Jordanian, Saudi Arabian Airlines, Sudan Airways, Syrian Arab Airlines, Trans Mediterranean, Tunis Air and Yemenia.

with a high concentration of the traffic centred in the Arabian Gulf states. The Middle East carriers also transported around 2.2 million tones of cargo in 2007, with Emirates responsible for over 45% of this freight (Air Cargo World, 2006). Figure 1 shows that the passenger traffic and cargo tonnage at Middle East airports increased by 120% and 110% respectively from 1998 to 2007. Steep increases in traffic were recorded from 2003 onwards, largely attributed to the extra capacity being added by Emirates, Qatar Airways and Etihad.

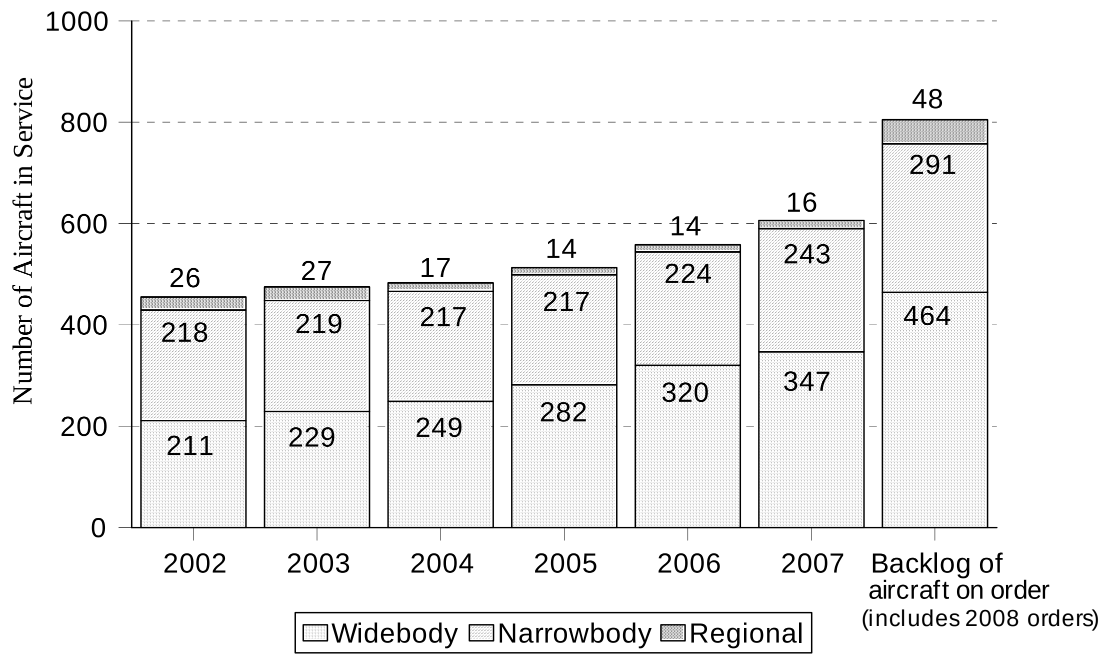
Figure 1 - Growth in Passenger and Cargo Traffic, and Aircraft Movements at Middle East Airports: 1998 – 2007



Sources: Arab Air Carriers Organization, Airports Council International

In 1988, the Arab carriers had a fleet of less than 150 aircraft with an average capacity of 170 seats, but by 2007 the fleet had expanded to more than 600 with an average capacity of 210 seats. Figure 2 shows that the narrowbody fleet was relatively unchanged from 2002 to 2007, while the number of widebody aircraft increased by 50%. The Boeing General Market Outlook (2007) indicated that around 39% of the world's fleet is composed of twin-aisle aircraft, with a further 4% composed of aircraft that are the size of a 747 or larger. However, the Middle East market is highly unique as around 57% of the aircraft in active service are widebodies. The 24 member carriers of AACO have around 800 aircraft on order, which is approximately equivalent to the combined fleets of Air France, British Airways, Cathay Pacific, Iberia and Singapore Airlines. A large proportion of the fleet that is on order by Middle East carriers is destined for Emirates, Qatar Airways and Etihad Airways. This represents a huge threat to European and Asian carriers as these three Arabian Gulf carriers will utilise their sixth freedom traffic rights to channel large volumes of traffic from spoke cites in Asia, Africa, Europe, Africa and the Americas through their respective hubs (i.e. Dubai, Doha and Abu Dhabi).

Figure 2 - Active fleet within the Middle East 2002 – 2007 and the backlog of aircraft on order



Sources: ACAS, Arab Air Carriers Organization

Table 1 below outlines the breakdown of airline traffic between the Middle East and the rest of the world from 1990 to 2007, and provides a forecast for 2027. It shows that the Middle East to Europe market is the region's most important sector, as it has the highest yield and is less competitive, because the European airlines schedule a large chunk of their long-haul capacity

Table 1 - Traffic growth (billions of RPKs) between the Middle East and the rest of the world 1990 – 2027

Middle East to:	1990	1995	2000	2001	2002	2003	2004	2005	2006	2007	2027F	% change 1990-1995	% change 1995-2000	% change 2000-2007	% change 2007-2027
Africa	7.4	6.5	9.8	10.6	13.2	13.9	13.9	16.4	17.9	19.8	64.0	-12.2%	50.7%	102.0%	223.4%
North America	6.6	10.3	16.1	12.0	10.4	9.6	12.6	14.4	19.6	29.9	94.2	56.6%	56.3%	85.7%	215.0%
Middle East	19.4	20.7	27.8	27.1	27.5	28.0	32.0	34.0	36.6	39.3	119.4	6.7%	34.3%	41.3%	203.8%
S.E. Asia	11.0	20.6	24.0	22.9	24.0	26.4	29.2	33.3	38.3	44.8	127.2	87.3%	16.5%	86.6%	183.9%
India/Pakistan	16.6	23.2	29.4	29.9	31.1	33.8	35.6	38.3	44.1	48.5	155.2	39.8%	26.7%	64.9%	220.0%
Europe	41.5	44.9	65.0	59.8	58.6	58.9	67.7	74.1	88.4	104.6	274.6	8.2%	44.7%	60.9%	162.5%

Source: Boeing Current Market Outlook 2007 and 2008 for the North Atlantic market, thus creating an opportunity for the Middle East based carriers. In 2007, Europe accounted for 36% of the Arab carriers' RPKs which is double that of its next largest market, the Indian subcontinent, closely followed by South East Asia. In essence, all regions between the Middle East and the rest of the world have grown substantially since the early 1990s. Asia is an important component of the master-plan of the Middle East based carriers, as the region has so many cities with very large population catchment areas, which can be connected via hubs in the Middle East to Europe, Africa, India and the East coast of North America. Traffic from Asia has grown by around 86% from 2000 to 2007 and is forecast to increase significantly.

The Middle East based carriers have capitalised on Africa's financially weak and under-funded airlines, as RPKs have grown by over 100% from 2000 to 2007 and Boeing estimates that these market pairs will register the highest growth rate over any of the other regions in the next two decades. They have also taken advantage of the underperforming state owned airlines of India and Pakistan, and from the rapid evolution of their deregulated international markets, as traffic is forecast to grow by around 220% over the next twenty years. Traffic between North America and the Middle East fell by around 40% from 2000 to 2003, primarily because of 9/11 and the conflicts in Afghanistan and Iraq. However, it recovered quickly and is forecast to grow by 215% by 2027. Only a few of AACO members offer services to North America and these include Egyptair, Emirates, Etihad, Kuwait Airways, Qatar Airways, Royal Air Maroc, Royal Jordanian Airlines and Saudi Arabian Airlines.

Panariello (2007) calculated that the Middle East based airlines earned around $20.6 billion in revenues in 2006, 21% higher than a year earlier, while the average operating margin registered just 3.9%. The Middle East based airlines as a whole (excluding Emirates) were expected to deliver around $200m in profit for 2008, indicating widespread losses among a large number of flag carriers (Bisignani, 2008).

3. DEREGULATION IN THE MIDDLE EAST

For decades, the Middle East air transport system has been heavily regulated. Negotiation of traffic rights is conducted within a bilateral system, with widely divergent levels of liberalisation existing within the region. Feiler and Goodovitch (1994) pointed out that the Middle East's air transport industry had stagnated because of its over-reliance on the oil industry, low levels of intra-regional trade and the institutionalised protection of its national carriers. Constraints in the allocation of traffic rights have posed a substantial barrier to the growth of new carriers. The region's first low cost carrier, Air Arabia, is for example only allowed to operate less than a daily service on the majority of its routes. Kaminski-Morrow (2006) reported that this new entrant carrier could expand its services five-fold if a pan-regional Open Aviation Area existed.

However, over recent years there has been a gradual progression towards liberalisation in the domestic, intra-regional and international markets of the Middle East. Domestic travel represents a very small proportion of total air traffic in most Middle East countries, with the exception of Saudi Arabia (around four times the size of France) and to a lesser extent Egypt. All flag carriers in their respective states have until recently fully controlled their domestic markets. Table 2 shows that domestic traffic in the Middle East states has been contracting except for Saudi Arabia and Egypt, while international traffic has been expanding rapidly despite the regulatory restrictions that are in place. Egypt has a large domestic air transport network and is the region's most populous state (around 80 million people). However, its regulatory regime is two-sided as Cairo remains closed and designated national carriers must operate in accordance with capacity controlled bilateral agreements, while all other airports have unrestricted access. This strategy has allowed Egyptair to hold on to 45% of the international traffic and retain a dominant position within the domestic market, as all feeder traffic from the airline's Star partners is carried between Cairo and other domestic points.

By contrast, the intra-regional and international markets are strikingly different. Services to the US, for example, operate under very liberal open skies agreements, but for intra-Arab routes the skies have been relatively closed. The Arab countries that have signed open skies agreements with the US include: Jordan (1996), UAE (1999), Bahrain (1999), Qatar (1999), Oman (2001) and Kuwait (2007). The open skies policies between the US and these Arab nations have acted as both a building block and a catalyst for changing the existing regulatory regime covering the intra-regional markets of the Middle East. This initial wave of liberalisation triggered the UAE, Bahrain[4], Kuwait, Oman and Lebanon to expand their open skies policies and allow foreign and newly established carriers the right to operate unlimited services into their territories.

Table 2 - Domestic traffic trends in the larger Middle East countries

	1990		2006		1990 - 2006	1990 - 2006
	Domestic Passenger Kilometres (millions)	Total Passenger Kilometres (millions)	Domestic Passenger Kilometres (millions)	Total Passenger Kilometres (millions)	% increase/decrease of Domestic Passenger km	% increase of Total Passenger km
Saudi Arabia	5,435	15,440	8,769	25,314	62%	64%
Egypt	430	4,430	635	10,556	48%	138%
Jordan	14	3,540	13	5,589	-7%	58%
Syria	52	1,135	29	2,340	-44%	106%
Yemen	135	608	101	3,035	-25%	400%

Sources: Feiler and Goodovitch, 1994 and ICAO 2007

3.1 THE EMERGENCE OF LOW COST CARRIERS IN THE MIDDLE EAST

In a similar manner to what transpired in Europe post-deregulation, low cost carriers have emerged to take advantage of liberalisation. In 2003, Air Arabia became the region's first budget carrier, operating out of Sharjah International airport in the UAE. By 2007, it was carrying 2.7 million passengers across the Middle East and to neighbouring states using 8 A320s, and accounting for 60% of Sharjah's traffic. The airline broke even in its first year of operation and has remained profitable ever since. Sine then it has been progressively reducing its break-even load factor to achieve a level of 63% by early 2008, while at the same time

[4] Bahrain has 69 air services agreements with other governments, 20 of which are based on the 'Open Skies' principles and foundations (Bahrain International Airport, 2007).

raising its load factor to 85% over the same period (Air Arabia, 2008). However, regulatory constraints by other countries within the Middle East have forced the carrier to operate with very low frequencies (3 to 4 times weekly), and to compensate for this it has had to expand its operations to serve 40 destinations in 20 countries - with the exceptions of Bahrain, Alexandria (Egypt) and Kuwait that are operated double daily as these states have open skies. OAG analysis reveals that around 27% of its seat capacity is used to serve the Arabian Gulf states, with a further 15% and 10% dedicated to other Arab and North African countries respectively.

To overcome these restrictions, Air Arabia has replicated the strategies of Air Asia and Tiger Airways by developing cross border ownership and management joint-ventures in Morocco and Nepal, setting up hubs in Casablanca and Kathmandu in the process. Low cost carriers often set up bases in nearby countries as their brand awareness becomes more established. However, Air Arabia has decided against this strategy, which may significantly impact its cost base as it must now invest large sums of capital into marketing programs in order to compete against well established brands. Its Moroccan partnership with Regional Air Lines will allow it to capitalise on the immense potential between North Africa and Southern Europe, as Morocco is the first North African country to establish an open skies agreement with the EU. Air Arabia ordered 10 A320s in late 2008 which are all earmarked for its hub at Casablanca. However, its joint venture in Nepal in conjunction with Flyyeti was suspended shortly after its inauguration, as a result of political and economic uncertainties. This strategy clearly demonstrates the ingenuity of Air Arabia in overcoming regulatory hurdles. The carrier's success and the open skies policy of the UAE have provided the catalyst for other low cost carriers to emerge, and by mid 2008 there were five such airlines[5] operating in the Middle East, which had captured around 4% of the market (Centre for Asia Pacific Aviation, 2008) and secured 12% of all the departures from the UAE (Sobie, May 2008).

The open skies arrangement in Kuwait allowed a Kuwaiti low cost carrier, Jazerra Airways, to commence operations in late 2005 and compete with Kuwait Airways. This second budget carrier operates A320s with a two-class seating configuration (36 business and 129 economy), and within two years of commencing operations it had transported 1.2 million passengers to 22 cities. During this time, it increased traffic between Kuwait and Alexandria by 35.6%, Kuwait

[5] Air Arabia, Jazeera, NAS Air, Sama and Bahrain Air.

and Amman by 19%, Kuwait and Beirut by 31%, and Kuwait and Damascus by 35%. By the end of 2007, Jazeera Airways had captured 11% of the Kuwait market (Aviation Business, 2006; Sobie, February 2008). Consistent with the strategies pursued by low cost carriers in the liberated markets of Europe, Jazerra Airways created a second hub in Dubai. Sobie (2007) indicates that the UAE, Kuwait and Oman have already fully opened their skies to low cost carriers, while Syria and Jordan may follow suit as the low-fare services benefits both the economy and population. Fanek (2007) reported that open skies could be critical to Jordan[6], as tourism has the potential to produce up to 10% of Jordan's GDP, up from today's 4%. The Middle East low cost carriers appear to be the driving force behind moves to deregulate intra-regionally.

Saudi Arabia has had one of the most restricted air transport policies in the world, giving Saudi Arabian Airlines a monopoly in its domestic market for almost 60 years. However, there has now been a major shift in the regulatory system with the country transitioning from a protectionist state to a more liberal one. It recently granted operating licences[7] to two new entrant low cost carriers - Sama (Dammam based) and Nas Air (Riyadh based). ICAO (2007) data indicated that almost 35% of Saudi Arabian Airlines total passenger kilometres was domestic traffic, around 2.4 million passengers per annum being carried between the country's two largest cities of Riyadh and Jeddah. In 2008, Sama and Nas Air were operating 22 and 28 weekly flights respectively between the two cities, while the flag carrier operated around 110 weekly services. Sobie (2007) expects passenger levels to soar to 4 million because of the competition[8]. In early 2008, the Saudi Government liberalised international services by allowing Sama to operate 19 international routes from the three main Saudi airports to Egypt, Jordan, Lebanon, Syria and the UAE, however it retained a restriction on the number of frequencies only allowing the carrier to operate on these routes once or twice a week. OAG analysis reveals that Sama had captured over 3% of the Saudi Arabian international market by mid 2008.

[6] There are three commercial airports in Jordan (two of which are located in Amman). Aqaba airport is a 45 minute flight from Amman and is a tourist destination that is located beside the Red Sea. The latter adheres to a full 'Open Skies' policy, while the airports in Amman remain closed.
[7] The operating conditions imposed on these carriers include mandatory flying of some public service obligation routes and respecting fare caps.
[8] Saudi Arabian Airlines charges the maximum fare permitted (Government-set price cap) of $72 on the Riyadh to Jeddah route, while NAS Air charges on average $33.

The fifth low cost carrier in the region is Bahrain Air, which started operations in 2008. It competes with Gulf Air on every short-haul route from Bahrain. OAG analysis reveals that it has already captured 7% of the Bahraini market, making it the second largest carrier after Gulf Air with 60% of the market. However, its business model does notfollow the classic LCC model, as it operates a two-class seating configuration, interlines cargo with KLM and code shares with Sama.

New entrant, FlyDubai, may well change low cost carrier dynamics within the Middle East - it is a subsidiary of Emirates and has ordered 54 Boeing 737-800 costing almost $5 billion, with the option to convert to Boeing 737-900s. It is expected to commence operations in mid 2009 from Dubai's new airport, located less than 50kms away from Sharjah airport – the base of Air Arabia. It plans to start operations to 12 destinations with the aim of building a network of around 70 routes.

The region's flag carriers are strategically focused on the threat posed by the budget airlines, with Saudi Arabian Airlines and Etihad Airways both studying the option of setting up their own low cost subsidiaries, while Qatar Airways has stated that it would launch a budget carrier within 90 days if low cost carriers begin to significantly impact its home market (Air Transport Intelligence, April 2007; April 2008; July 2008).

4. TOWARDS A PAN-REGIONAL AGREEMENT ON LIBERALISATION

There are two patterns of liberalisation emerging in the Middle East. Firstly the GCC states are aiming to create a single market. Legislation passed in 2003, allowed goods to be moved between member states without being subjected to the usual customs duties and inspections. The integrated market would offer equal opportunities for all GCC citizens including the right to work in all government and private institutions in member states, buy and sell real estate and make other investments, move freely between the countries, and receive education and health benefits. Plans for a common currency between member states may become a reality by 2010 (Arab News, 2008). This type of integration is similar to what occurred to the European Union in the early 1990s and it may trigger an open skies policy to be formulated between the six members of the GCC states, however this is speculative but at the same time it could become a distinct possibility.

The second pattern of liberalisation that is emerging out of the Middle East is associated with a specific committee called the Arab Civil Aviation Commission[9] (ACAC). This association is actively leading its members towards adopting an open skies policy as part of the Arab League's road map for the liberalisation of air transport.[10] Pinkham (2004) stated that this document essentially provided the 'nucleus of a single aviation market' for the region. A significant step forward took place between 2004 and 2007 with the signing and subsequent ratification of a multilateral agreement on air transport liberalisation among Arab countries, including access to fifth freedom rights on a bilateral basis. Table 3 shows that Jordan**,** Lebanon, Palestine, Syria, Yemen and the UAE have now ratified the agreement, which is an important initiative that should trigger more competition and higher rates of intra-Middle East traffic growth. Other states which have signed the treaty, but have not yet ratified it include Algeria, Bahrain, Iraq, Egypt, Mauritania, Morocco, Oman, Somalia, Sudan and Tunisia. As adoption of this multilateral agreement increases, it will accelerate the process of change also at the bilateral level, with state policies increasingly being influenced by changes in the international marketplace (AACO, 2007). At the AACO 2008 AGM, its member airlines appealed to their respective governments to: investigate the optimisation of air routes by making them more direct; rethink taxation policies on airlines and airports; insist that privatised airports do not take advantage of their monopoly positions; and allow freer movement of people between Arab nations, as many still enforce strict visa rules. ACAC was also asked to look into permitting cross-border equity stake-holding of the Arab airlines, which could pave the way to reaching a single Arab air transport market, similar to that which the European Union had established (AACO, 2008). However, the lack of a pan-Arab regulatory body to govern the ACAC presents a major challenge to the realisation of a multilateral regime.

[9] ACAC has 16 Member States: Bahrain, Egypt, Iraq, Jordan, Lebanon, Libya, Morocco, Oman, Palestine, Qatar, Saudi Arabia, Sudan, Syria, Tunisia, United Arab Emirates and Yemen.

[10] Some African countries have multiple affiliations with different liberalisation programs both in Africa and with the Arab nations. Algeria, Egypt, Libya, Morocco, Sudan and Tunisia are affiliate members of ACAC and signatories to the Yamoussoukro II Declaration, which contains the terms for liberalising air transport across the entire African Continent. Egypt, Libya and Sudan are also members of ACAC and COMESA (Common Market for Eastern and Southern Africa).

Table 3 - Signatory states to the ACAC Liberalisation Agreement (2008)

Country	Signed the ACAC Agreement	Ratified the ACAC Agreement
Algeria	Yes	No
Bahrain	Yes	No
Egypt	Yes	No
Iraq	Yes	No
Jordan	**Yes**	**Yes**
Lebanon	**Yes**	**Yes**
Mauritania	Yes	No
Morocco	Yes	No
Oman	Yes	No
Palestine	**Yes**	**Yes**
Somalia	Yes	No
Sudan	Yes	No
Syria	**Yes**	**Yes**
Tunisia	Yes	No
UAE	**Yes**	**Yes**
Yemen	**Yes**	**Yes**

Note: Those countries that are outlined in bold have both signed and ratified the treaty
Source: Arab Civil Aviation Commission (ACAC)

The provisions of the agreement will provide the region with a new set of rules that closely resemble those embodied in the EU's Third Package. ACAC envisions that the Middle East will replicate the stepping-stone approach that was used in Europe as the way forward to introduce deregulation into the region. The objectives of the ACAC liberalisation agreement involve the establishment of a 'vast Arab free trade zone' to foster regional and international economic development, thereby freeing the intra-regional movement of passengers, goods and capital (ACAC, 2004). In an intra-regional context, the terms of the agreement permit, with the exception of domestic cabotage, licensed carriers to access all markets within the region –

without controls on the determination of capacity or tariffs – and allow cross-border ownership with the proviso that carriers have their ownership and effective control in the hands of nationals of states party to the agreement. Teffaha (2008) stated that Arab governments need to open up and adopt liberal air transport policies as they have reached a regulatory crossroad. Optimism with regard to a more liberalised operating environment is arguably high: a recent survey of 300 industry executives revealed that over two thirds of respondents viewed the easing of restrictions on aviation traffic rights by the region's governments as likely (Aviation Business, 2007). Nevertheless, the agreement in its current form contains significant weaknesses; these principally stem from an absence of an executive authority and pan regional framework to oversee and arbitrate in matters of competition. Whereas the EU single aviation market falls under the competition rules enshrined in Articles 81-89 of the Treaty of Rome, which forms the basis of the European Community, the OAA proposed by the ACAC agreement is conceived without equivalent binding legislation. Table 4 outlines the provisions of the agreement.

Table 4 - Provisions of the ACAC agreement compared with the EU Third Package

Legislation	ACAC Agreement Pact	EU Council Regulation
Licensing and ownership of airlines	**Section 3, Article 5/2a** Air transport operating licence to be available to one or more carriers in each Party State provided that 'The substantial ownership and actual control of the [airline] is under one or more Party Countries or Citizens thereof and the main head office of the Company activities is located in one of the Party Countries'.	**2407/92, Article 4/1a and 4/2** Air transport operating licence to be granted by a Member State only if a [carrier]'s: 'principal place of business and...registered office is located in that Member State', is 'owned and continue[s] to be owned directly or through majority ownership by Member States and/or nationals of Member States' and 'at all times be effectively controlled by such States or such nationals'.

Granting of Traffic Rights	**Section 2, Article 2/a/b/c** Appointed carriers are granted the following rights when operating scheduled services between Party Countries: 'The right to transit at any territory of the other Party Countries' territories'; 'the right to land at any territory of the other Party Countries' territories for non-commercial purposes'; 'the right to load/ unload goods, passengers and mail whether separately or jointly to the Party Countries' territories'. Cabotage rights are <u>not</u> granted.	**2408/92 Articles 2/2f and 3/1** Whereas under 2/2f, 'traffic right' is defined as 'right of an air carrier to carry passengers, cargo and/or mail on an air service between two Community airports', under 3/1 'Community air carriers shall be permitted by the Member State(s) concerned to exercise traffic rights on routes within the Community'. Cabotage rights are granted.
Capacity Controls	**Section 3, Article 7/1** Appointed air carriers 'may operate the capacity and number of flights as they may deem appropriate, and by any aeroplane model to operate air services among the Party Countries'.	**2408/92, Article 10/1** 'Capacity limitations shall not apply to air services covered by this Regulation' with the exception of necessary regulating of capacity within an airport group (Article 8) or for environmental reasons (Article 9).
Tariffs	**Attachment 1/1 and 1/4** Appointed carriers belonging to Party Countries 'shall set the air transportation tariffs on the basis of market commercial considerations', 'none of the air transportation tariffs among the Party Countries requires the approval of the Civil Aviation Authorities'.[1]	**2409/92, Article 5/1** 'Without prejudice to this Regulation, Community air carriers shall freely set air fares.'

[1.] Under the ACAC agreement (Section 3, Article 8/2), notification of fares must be made to the relevant Civil Aviation Authority no less than thirty days prior to fares being made available – this contrasts with the provisions of 2409/92, Article 5/2 which stipulates that no more than 24 hours notice before fares come into effect need be provided to the relevant Civil Aviation Authority.

Sources: ACAC 2004; European Council 1992a; European Council 1992b; European Council 1992c; Abuel-Ealeh (2007).

The Arabesk Alliance provides evidence that this ACAC multilateral agreement between Arab member states has the potential to succeed. A number of carriers have worked together and created the first pan-Arab airline alliance, which comprises EgyptAir, Etihad Airways, Gulf Air, Middle East Airlines, Royal Jordanian Airlines, Saudi Arabian Airlines, Syrian Arab Airlines, Tunisair and Yemenia. The alliance is aimed at reducing the duplication of capacity, linking networks and destinations, generating market demand through improved customer connectivity, maximizing capacity utilization through route sharing and rationalization, and achieving efficiency through cooperation. However, it is too early to forecast the potential impact of this pan-regional alliance whose primary weakness is its inadequate global reach.

5. CONCLUDING COMMENTS

The spotlight of international attention has long been focused on the Middle East because of its vast reservoirs of petrochemicals and its tumultuous history of conflict. Its once dormant aviation industry has been transformed into a thriving industry. The region's carriers have orders for around 800 aircraft and this president is set the change the dynamics of the global air transport industry.

The Middle East remains regulated but this process is slowly evolving as low cost carriers are pushing the regulatory barriers, similar to what has occurred in Asia. The low cost carriers have acquired around 4% of the Middle East market and the open skies policy adopted by the United Arab Emirates has allowed these carriers to flourish by opening bases, which has allowed them to capture a sizable chunk of the UAE market. The rapid success of these new entrant carriers in the region demonstrate once again that the developments that we have come to expect from deregulation can be replicated anywhere in the world. There are two patterns of liberalisation emerging in the Middle East. Firstly the six GCC states which are classified as the engines of the Middle East are in the process of constructing an integrated economic and social policy with the aim of creating a single market. This in turn may trigger an open skies policy between these states. Secondly, a liberalisation process is underway that engages 16 member states under the auspices of ACAC, which also encapsulates some of the GCC states. It closely replicates the blueprint of the EUs third package, which transformed Europe's bilateral agreements between member states into an open skies platform. The agreement will allow carrier access to all markets without any restrictions on capacity or tariffs, while at the same time permitting cross border ownership. The sole restriction of the agreement is that the rules that govern cabotage will apply. All this implies that the Middle East wants regulatory change and the low cost carriers may very well provide the stimulus to expedite this process.

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A Driver-Based Approach to Airport Valuation

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ABSTRACT

This paper presents the first part of results of extensive research on an alternative concept to airport valuation. It reviews traditional and alternative valuation measures, illustrated by a sample of eight publicly quoted European airports. The main objective is to derive a model taking account of the underlying key value drivers.

A peer group analysis shows that only few sector multiples applied by the investors' community are significantly correlated with key performance indicators based on business fundamentals. By contrast to the results of this alternative driver-based valuation approach, these market multiples are affected by stock market fluctuations and do not adequately reflect the financial position and true value, and hence supports this paper's view that airports should be valued by recognising key success factors.

KEYWORDS: Airport Benchmarking, Valuation, Performance, Finance, Privatisation, Europe.

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1. INTRODUCTION

The main aim of this research is to establish an alternative valuation concept which is firmly based on the key value drivers of the airport business. Since financial results reflect a company's achievements over a diverse array of activities, they are arguably by far the most important dimension of performance. Consequently, this paper focuses on instruments and techniques for measuring the financial performance and economic value of airports and to provide an adequate framework derived from the Du Pont-System of Financial Control.

While airports may be attractive businesses, they are not equally appealing. Some are more profitable than others and airports have sold at varying earnings multiples. Therefore, investors and financial markets as well as other interested parties like airlines and academics need to develop the ability to assess the performance and relative attractiveness of airports. From an investor's perspective, profitability or cash earnings available for the distribution to shareholders is the central issue of any performance appraisal. At a basic financial level, the relative attractiveness and associated value is a function of the 'airport value tree', based on the Du Pont-Chart which decomposes return ratios into components. The 'airport value tree' is a refined application of the Du Pont-ROI model to the airport world (for conceptual details see e.g. Palepu, 1997; for sector applications see Morgan Stanley Dean Witter, MSDW, 2000, and Vogel, 2006).

The airport sector is characterised by a high degree of corporate activity which has resulted in an unprecedented level of investor interest in gaining exposure to the dependable and growth characteristics of airport investments. Every time an airport sounds mildly interested in privatising, financial institutions seeking underwriting and advisory fees, construction and consulting companies, other interested airports themselves and other firms involved line up to investigate. This interest is easy to understand. Revenue from fees and concessions are relatively steady, stable and almost risk-free.

Europe's airports have emerged as attractive investment opportunities for the private sector. Many airports are large businesses, providing a complete range of essential services to a broad customer base. They represent a growth business which is relatively recession-proof and commands premiums. Many are essentially 'monopoly suppliers' with limited real competition in the local marketplace and relatively high entry barriers. They are high-utilisation assets, in use 365 days a year. While short-distance travellers may increasingly opt for high-speed rail links, long-haul passengers can be viewed as captive to this mode of transport. Although they may have a choice between competing airports for some destinations, they will be using the air transport system – and demand is growing rapidly. In short, the relatively low competitive intensity of much of the industry makes airports structurally attractive as investments because the expected earnings are likely to be favourable and above average.

With the new approach of the airport business there is also an increasing interest in monitoring and comparing the performance and corresponding value of individual airports. Performance measures generally describe the relationship between inputs and outputs. The areas of primary interest obviously differ as the particular focus does. Airport managers concentrate on operational aspects, so as to understand how efficiently the airport is using its infrastructure and how cost effectively it is doing so. The finance sector is more interested in comparative levels of commercial revenue and its relationship to aeronautical revenue, liquidity ratios and capital expenditure levels. Those advising investors will definitely look at a wide range of measures covering all aspects of performance, in order to judge the potential for performance improvements once an airport has been privatised.

There are now a number of established techniques for assessing airport performance, each with their own advantages and disadvantages. These include the analysis of partial factor productivity, total factor productivity and financial metrics. Each method will cover different aspects of performance, and have different data and assumptions requirements, which can potentially mean that these various techniques can yield slightly varying results. These can only be meaningfully interpreted by having a thorough understanding of what each approach is actually measuring. For further details see Graham (2005).

The structure of this paper is as follows: Section 2 introduces the eight sample airports and presents the results of partial factor productivity and financial ratio analysis. Section 3 provides the methodological basis for a driver-based valuation approach. Section 4 contains a correlation analysis of the key performance indicators of the alternative driver-based valuation model versus market-driven valuation multiples. The main results of the first stage of this research are summarised and put into real-life context in section 5, which also indicates the next steps of the ongoing work.

2. BENCHMARKING ANALYSIS OF EUROPEAN AIRPORTS

There has been an increasing number of airport performance evaluations discussed in the academic literature. In addition, there are a number of recent studies which have compared the different performance methods which exist. A detailed overview of the individual applications is provided by Vogel and Graham (2006).

Table 1 - Sample of European Airports as of 2006

IATA Code	Airport Company / Publicly Quoted Entity	IPO Year	ATM	PAX (000)	Air Cargo (t)
ADP	Aéroports de Paris SA	2006	762,332	82,500	2,240,000
BAA	BAA plc*	1987	1,028,200	116,200	1,399,988
CPH	Copenhagen Airports A/S	1994	258,356	20,877	380,024
FLR	AdF-Aeroporto di Firenze SpA	2000	27,521	1,531	205
FRA	Fraport AG	2001	489,406	52,811	2,127,800
VCE	SAVE SpA Group**	2005	99,349	7,683	46,292
VIE	Flughafen Wien AG	1992	237,490	16,856	265,778
ZRH	Unique Flughafen Zürich AG	2000	260,786	19,237	363,325

Note: *delisted in 2006; traffic data for the 9 months period 1 Apr – 31 Dec only; **incl. Treviso

Since measuring airport performance is a prerequisite for valuation, the eight publicly listed European airport companies introduced below have been benchmarked by means of partial factor productivity (PFP) and financial ratio analysis (FRA). Principal sources of data are the respective reports and accounts complemented by sector research published by stock brokers regarding valuation multiples. Aspects of airport service quality have not been explicitly considered. Geographically, the scope has been restricted to Europe, since all sample airports enjoy similar market as well as operational conditions and are subject to the same kind of overall economic and thus traffic development. Moreover, airport privatisation was initially only a European phenomenon, and has resulted in the only existing representative peer group.

Table 2 outlines the main indicators of partial factor productivity and financial ratios calculated for the period 2004-2006, categorised into five major areas of performance measurement:

profitability, revenue generation, cost efficiency, debt and asset management, as well as capital productivity.

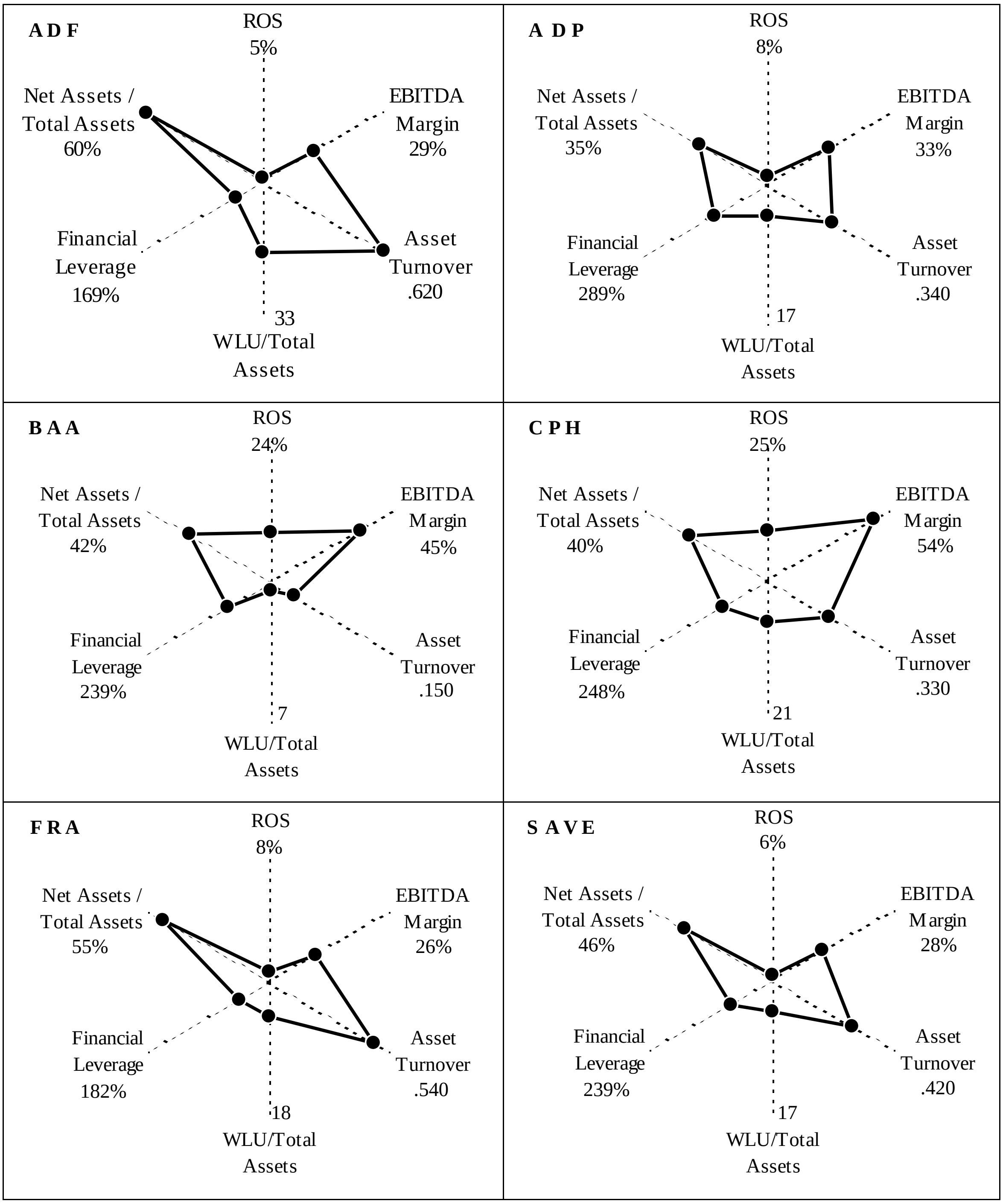
Table 2 - Benchmarking Results of Sample Airports (Arithmetic Means 2004-2006)

PFP / FRA Indicator / Ratio	ADF	ADP	BAA*	CPH	FRA	SAVE**	VIE	ZRH
Profitability:								
Profit/WLU (€)	1.01	1.52	4.96	3.78	2.43	1.52	4.11	1.54
RevEx	1.06	1.08	1.32	1.33	1.09	1.06	1.20	1.08
ROA (%)	3.48	2.58	3.69	8.00	4.38	2.36	6.34	1.75
ROS (%)	5.45	7.55	24.09	24.53	8.13	5.89	16.86	7.67
ROE (%)	5.74	7.49	8.71	19.73	7.99	5.38	11.02	5.56
EBITDA Margin ***	28.58	32.53	45.43	53.99	25.70	27.57	35.95	51.26
Revenue Generation:								
Total Revenue/WLU (€)	18.59	20.26	20.66	15.39	29.86	25.23	24.36	20.01
Total Revenue/Currency Unit of Shareholders' Funds (€)	1.04	1.00	0.36	0.80	0.99	1.04	0.65	0.77
Cost Efficiency:								
Total Cost/WLU (€)	17.57	18.73	15.70	11.62	27.43	23.71	20.25	18.48
Debt & Asset Mgmt:								
Financial Leverage (%)	168.9	288.6	239.2	247.8	182.0	239.4	176.9	348.9
Debt Ratio (%)	40.33	64.61	57.93	49.57	45.04	54.48	42.67	70.14
Gearing (%)	68.90	188.59	139.18	147.76	81.97	139.37	76.85	248.91
Net Assets in % of Total Assets	59.67	35.39	42.07	40.43	54.96	45.52	57.33	29.86
Capital Productivity:								
Asset Utilisation	33.46	17.02	7.48	21.12	18.16	16.80	15.39	11.06
Total Assets/WLU (€)	30.37	59.00	139.99	47.51	55.16	62.35	65.95	90.71
Total Assets/ATM (€)	1,606	7,934	17,826	4,187	8,161	4,643	5,214	7,445
Total Asset Turnover (x)	0.62	0.34	0.15	0.33	0.54	0.42	0.38	0.22

Note: monetary data converted to EUR; * FY 2006 data for the 9 months period 1 Apr – 31 Dec; ** airport SBU accounts for ~ 75% of Group EBITDA; Source: own calculations based on company data, *** various brokers' research

The PFP and FRA results reveal distinct differences between sample airports across the individual categories. Figure 1 illustrates the major value drivers or roots of value creation according to the 'airport value tree'. Since airports primarily create value by converting traffic into revenue through the provision of infrastructure and related services, their value tree is rooted in aircraft movements and passengers and disaggregates return ratios generated by the business in profit margin and turnover elements. This concept – based on the Du Pont-ROI model summarising the relations between return on investment (assets), asset turnover, the profit margin and financial leverage – is vital to valuation.

Figure 1 - Performance Profiles of Sample Airports (Average FYs 2004-2006)



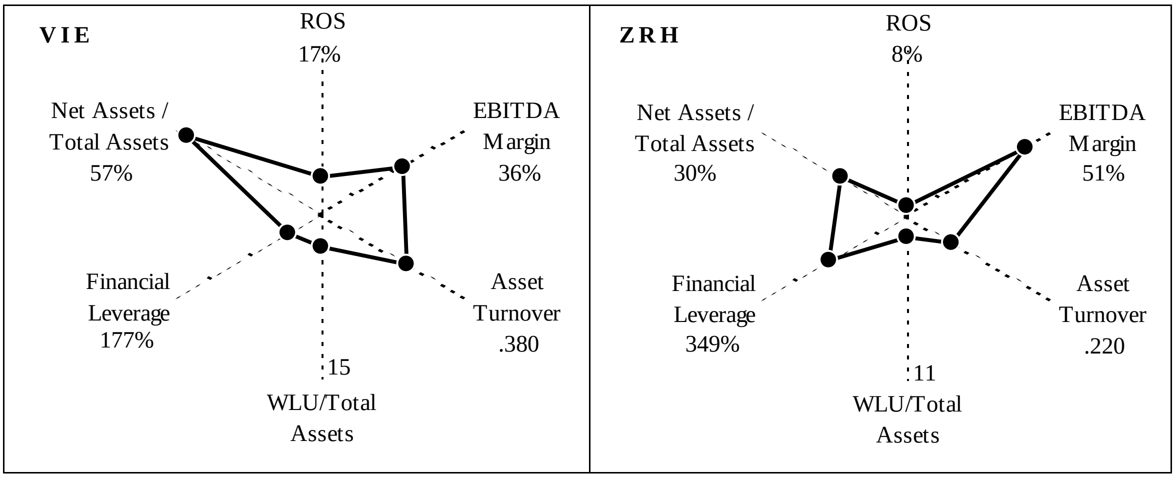


Figure 1 visualizes the main determinants of value creation in terms of Performance profiles of the eight sample airports. It pinpoints strengths and weaknesses like a value driver scorecard, facilitating sector comparisons. The profiles illustrate the marked differences in terms of operating efficiency, represented by ROS and EBITDA margin. The ratios of WLU/total assets and total asset turnover stand for asset utilisation or capital productivity. Capital structure is reflected by the percentage of net assets to total assets and financial leverage. These three key performance indicators (KPIs) summarise the underlying value drivers or roots of value creation, such as traffic volume (and growth), efficiency, regulatory regime, diversion strategy and capital management. They all exert an immediate impact on profitability and valuation.

It becomes quite obvious from these benchmarking results discussed above that airports are different on a number of criteria and that not all earnings are created equal. Hence different values may be associated and different pricing attached. In general, it is management's primary goal to maximize shareholder wealth, which translates into maximizing the value of the firm. For quoted airport companies this value is measured by the price of their common stock. The stock market evaluates every facet of a business in a nutshell, expressed by the investors' appreciation of the respective shares. The principles of company value and some specific valuation measures will be described next.

3. VALUATION ISSUES

3.1 TRADITIONAL VALUATION MEASURES

A common tool for judging the real business performance, as reflected by the investors' demand for an equity share in an airport company, is assessment of the actual stock price relative to the overall development of the respective capital market. Price and price relative charts can plot the market price of the respective equity (airport) together with its price relative to the local market index. But against the background of the overall economic or investment climate are the business fundamentals and their impact on the value drivers which are the principal determinants of financial and ultimately share price performance (Damodaran, 1996; O'Connor, 1996; Ryland, 2000).

A company's share price is mainly driven by its price to earnings (P/E) ratio. Higher ones imply that the market expects faster-than-average future growth from these stocks in intra-sectoral comparison, and vice versa. P/E bands plot chart lines at specified price earnings levels depending on the earnings per share (EPS) record of the respective security. The charts plot the historical price overlaid with bands which are EPS multiples. Typically, multiples are entered so that the top band passes through the high and the bottom band passes through the low price. In general, P/E bands measure the progress of the stock in relation to its actual earnings and serve as an indicator to project the future share price based on expected earnings (Damodaran, 1996; O'Connor, 1996; Ryland, 2000).

Airport stocks are particularly vulnerable with regard to external events affecting the aviation industry as a whole. Moreover, airports face conflicting interests, such as business, politics, environmental protection, regulatory authorities and neighbouring communities. In particular political controversies and environmental concerns are hampering growth. Owing to the very nature of the business, airports operate with high fixed costs and limited flexibility with regard to traffic downturns which also has a direct impact on the majority of revenue sources. On the other hand, airports frequently have sound balance sheets and assets which consist almost entirely of long-term tangible fixed assets. Despite recent developments traffic growth is likely to outpace GDP growth and locally speaking, airports are arguably quasi-monopolies and entry barriers for competitors are high (Airbus, 2007; HypoVereinsbank, 2002).

Historical share performance, of course, can only give limited guidance and expected future earnings are key to the valuation and share price performance of any business. Apart from external effects and hostile takeovers, it is basically the investors' perception of likes and dislikes which are anticipated by the stock market and determine the respective share price. Investors' likes include everything bearing the potential for sustained growth in volume and earnings (such as strength of carrier/passenger base, capacity/investment cycle, regulatory framework, environmental constraints etc.) – and vice versa. As with any other business entity, an airport is valued on the basis of its current and expected revenues, earnings and cash flow. With regard to the stock market, it is useful to differentiate between traditional single-period and alternative multi-period approaches to evaluate a business.

Traditional valuation measures are performance indicators for the very near future. The earnings and enterprise value multiples are calculated on the basis of historical data and projected for the next one to three years. The price/earnings (P/E) and price/cash flow (P/CF) ratios are the most important ones and frequently used by analysts and investors. Despite their simplicity, different depreciation policies in the sector may have an impact on comparative earnings per share (EPS) valuations. Therefore, cash valuations are the key comparatives for international airports and price/cash earnings per share (P/CEPS) multiples appear to be more appropriate for comparison (UBS, 1996; Ryland, 2000).

Table 3 compares some additional airport valuation measures as applied by the finance community. The initial problem is that there still are only a small number of airport operators for drawing comparisons, exacerbated by the lack of uniformity provided by traditional valuation measures. There may also exist variations in the actual level of these ratios due to the differences inherent in the individual airport companies. A major methodological weakness of these static snapshot valuation measures is that they are based on constant share prices and market capitalisation (number of shares outstanding x share price). This does not reflect the dynamics of the business and results in rather 'stable' multiples.

Still, the enterprise value multiple EV/EBITDA, defined as the ratio of market capitalisation plus net debt (EV) versus earnings before depreciation, interest and taxes, seems to provide one useful basis for comparative valuation of the sector. The reason for this is that it fluctuates far less over the investment cycle – which will be elaborated on next – than other traditional earnings measures. The downside of less fluctuation, however, is concealment of the considerable depreciation effects on accounted earnings.

Table 3 - Traditional Valuation Measures of Publicly Quoted Airport Companies

Airport/ Year	Share Price (€)	Market Cap (000 €)	EV/ Sales (x)	EBITDA Margin (%)	EV/ EBITDA (x)	EV/ EBIT (x)	P/E-Ratio (x)	Div. Yield (%)
ADF 04	10.60	95,768	3.60	31.80	13.10	-	94.20	0.40
ADF 05	15.48	139,858	4.15	31.85	14.20	-	55.30	1.00
ADF 06	18.67	168,679	5.63	22.10	17.54	47.30	71.70	1.40
ADP 04	0.00	0	-	35.00	12.00	-	33.85	-
ADP 05	47.60	4,063,207	3.52	31.83	13.42	-	33.82	1.12
ADP 06	74.01	7,324,074	4.26	30.77	13.64	22.95	38.60	1.25
BAA 04	8.87	9,548,941	4.63	-	10.60	14.30	18.90	4.10
BAA 05	13.56	14,651,300	4.21	46.07	12.03	-	18.83	2.77
BAA 06	0.00	0	-	44.80	15.70	-	23.10	2.40
CPH 04	161.89	1,348,515	5.35	-	9.15	14.00	17.15	-
CPH 05	242.65	1,904,344	6.55	52.25	14.38	18.90	24.03	3.47
CPH 06	305.86	2,400,447	7.27	55.73	13.10	16.17	23.82	4.44
FRA 04	31.34	2,840,617	1.33	25.50	6.48	9.50	21.55	2.90
FRA 05	59.96	5,467,894	2.33	25.37	9.21	18.00	29.11	1.70
FRA 06	54.89	5,021,246	2.43	26.23	9.17	15.70	23.91	2.14
SAVE 04	10.74	214,800	-	30.60	15.30	-	96.45	-
SAVE 05	10.90	301,603	4.25	28.10	13.75	-	42.93	1.70
SAVE 06	13.17	364,414	4.45	24.00	11.43	14.70	32.63	2.20
VIE 04	52.00	1,092,000	2.50	-	7.47	9.75	16.13	-
VIE 05	63.04	1,323,840	3.05	35.60	9.92	13.10	18.85	3.02
VIE 06	77.71	1,631,910	3.79	36.30	10.35	15.40	20.82	2.83
ZRH 04	110.84	544,478	4.15	-	9.30	21.95	46.90	-
ZRH 05	171.95	844,664	5.00	51.65	10.04	19.90	27.18	0.63
ZRH 06	295.82	1,816,468	5.40	50.87	10.82	22.90	35.91	0.71

Note: BAA delisted 15 August 2006 after takeover by Grupo Ferrovial; SAVE airport SBU accounts for ~ 75% of Group EBITDA; Source: Datastream, Yahoo Finance, various brokers' research, own calculations

The traditional ratio-based methods of valuation introduced above undoubtedly serve a useful function. In particular, the use of EBITDA appears to exhibit some correlation in valuation between the quoted airport companies. But investors will wish, no doubt, to use a number of different valuation tools. From the investors' point of view, alternative valuation techniques such as the discounted cash flow approach (DCF), the combined valuation of the sum-of-the-parts

(SOTP) and/or a valuation of the regulated asset base (RAB), may provide a superior means of establishing a long-term valuation in addition to traditional stock market-related measures. One advantage of the SOTP approach is to account for the diversity of individual business units/segments, while the RAB approach focuses on airside operations and usually neglects necessary investment to maintain the achieved position and to generate future earnings. Yet, no method can be considered definitive (Damodaran, 1996; ABN-AMRO, 2006; MorganStanley, 2006; JPMorgan, 2006).

One long-established alternative valuation technique is the (multiple stage) discounted cash flow approach. Rather than looking at the short-term snapshots of P/E ratios or EV to EBITDA, it is aimed at the medium- to long-term valuation of a business, providing interesting insight for investors. Generally, the DCF-method determines the enterprise value of a firm by discounting the stream of cash flows at the weighted average opportunity cost of capital of the firm. Key components of this concept are the estimated free cash flows, the terminal value of the company at the end of the forecast period and the weighted average cost of capital (WACC) (Damodaran, 1996; Ross et al, 1996; Weston et al, 1996).

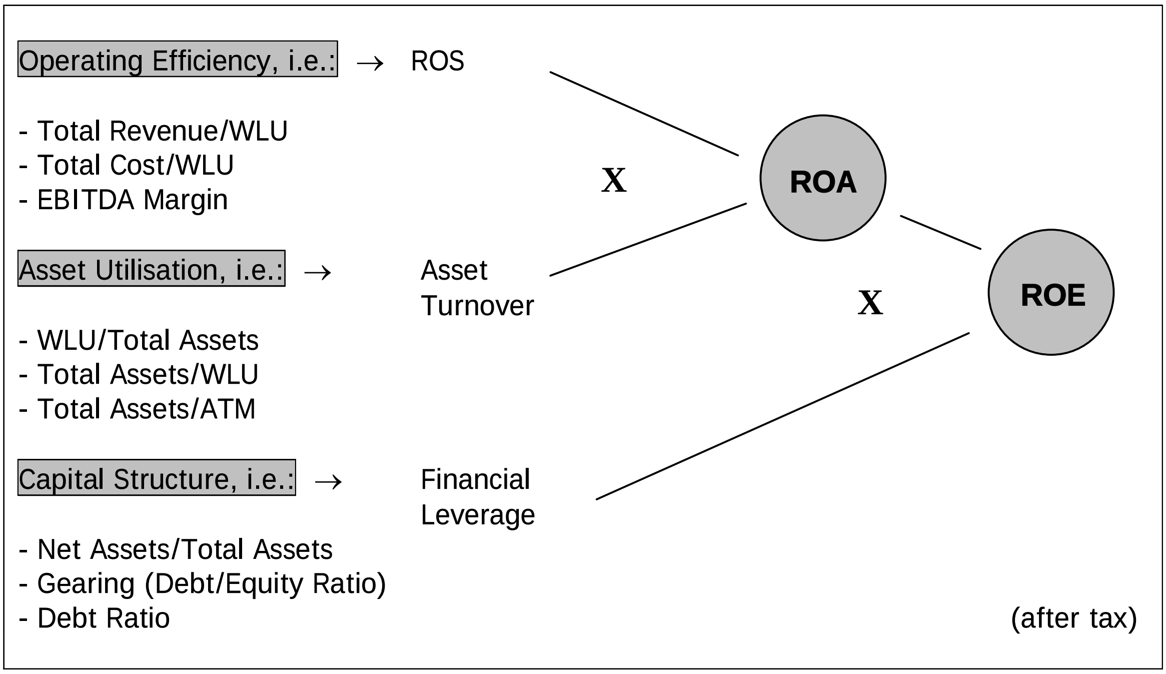
The discounted cash flow methodology involves forecasting the operating free cash flows, which will reflect the earnings before depreciation and interest, less capital expenditure plus changes in working capital and adjusted for corporation tax. Then the internal rate of return is calculated which discounts these future cash flows back to the present enterprise value, defined as current market capitalisation plus net debt. This procedure allows one to 'look through' the investment cycle and constitutes a long-term model which reveals the generated return rate. It provides useful insight into a longer-term valuation framework by looking through the investment cycle (Damodaran, 1996; SBC Warburg, 1996, 1997).

Although rather straight forward in conceptual terms, establishing integrated DCF-models is a complex exercise, which is clearly beyond the scope of this paper. Examples of (primarily) listed airports are included in brokers' research, e.g. ING (2005), Davy (2006), Morgan Stanley (2006) or Sal. Oppenheim (2006). In accordance with the focus of this research, the underlying key success factors and value divers which are so crucial to the business and essential for any valuation attempt will be analysed instead.

3.2 KEY SUCCESS FACTORS AND VALUE DRIVERS

With any valuation method, identifying and understanding key success factors or value drivers is a prerequisite for controlling them and for creating shareholder value. As per the mechanics of the 'airport value tree' and results of earlier research (Vogel, 2006) the key value drivers of the airport business within a given framework of traffic demand and regulatory control have been identified as operating efficiency, asset utilisation or capital productivity and capital structure. The key drivers themselves, in turn, are influenced by various factors. Each of those have an immediate impact on the return rate generated by the airport's assets and ultimately on the return rate which may attract investors, as illustrated by Figure 2.

Figure 2 - The Roots of Key Value Drivers and their Effect on Returns



Return on sales is primarily dependent on operating efficiency, which is driven by revenue generation, cost management, and the EBITDA margin. Asset turnover is dependent on 'sweating' the assets in terms of high asset utilisation or faster growth in revenues than assets. The product of return on sales and asset turnover results is the return on assets. The return rate generated by the airport's assets multiplied by financial leverage, which is determined by capital structure, finally results in return on equity. Tax deductible interest expense lowers net income, thus decreasing ROA. The use of debt, however, decreases equity and as long as equity is lowered more than net profit, ROE will increase. Figure 2 emphasizes that the rationale of this driver-based valuation approach is the framework provided by the 'airport value tree'. The value tree is predicated on the Du Pont-Chart, which disaggregates return ratios in the profit margin and turnover elements.

4. THE ALTERNATIVE DRIVER-BASED VALUATION APPROACH

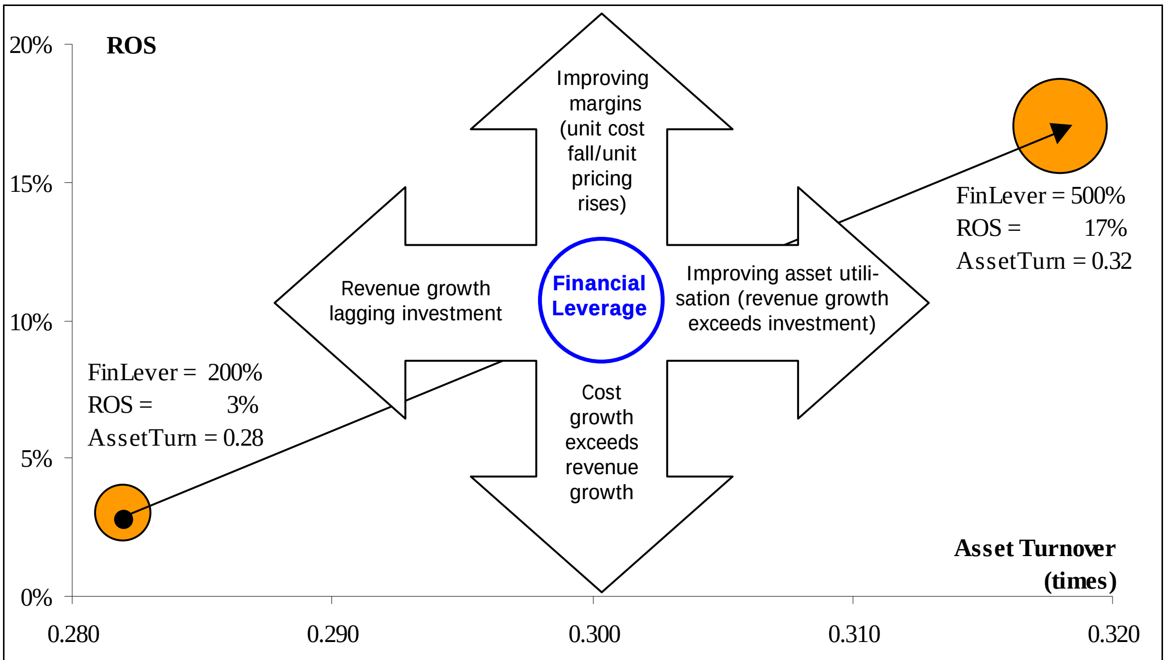
4.1 VALUE PROFILES OF EUROPEAN AIRPORTS

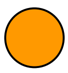
The implications of the investment cycle for earnings, productivity and financial ratios and ultimately for the share price performance of quoted airport companies are paramount. Therefore, conventional valuation measures are not particularly helpful tools for long-term evaluation of airport companies. Based on the key value drivers operating efficiency, asset utilisation/capital productivity and capital structure value profiles may be established for the sample of eight European airports for the period under consideration.

Like the discounted cash flow analysis, visualizing value profiles is actually an alternative valuation approach, as opposed to traditional techniques or conventional earnings multiples such as the short-term snapshots of EV/EBITDA and P/E-ratios as described during the discussion of share price performance. While DCF aims at looking through the investment cycle establishing a long-term valuation, the value profiles below are initially based on historical data. The very merit of this approach as opposed to the other valuation techniques is, however, that it gives a clear picture of the underlying drivers involved and the direction as well as magnitude of improvements required in order to noticeably increase financial performance – and it clearly reduces the problem of predicting earnings.

The framework for visualizing value profiles is illustrated in Figure 3. The dimensions of this chart, asset turnover on the x-axis, ROS on the y-axis and financial leverage, represented by the size of the bubbles, are made up of the three KPIs or main drivers of returns. The compass card explains the economic meaning of the respective positioning of an airport within this coordinate system, at the same time indicating actions for improvements. Furthermore, plotting paths over time allows for keeping track of changes of individual airport companies and sector benchmarking.

Figure 3 - Framework for visualizing Value Profiles – The three Drivers of Returns



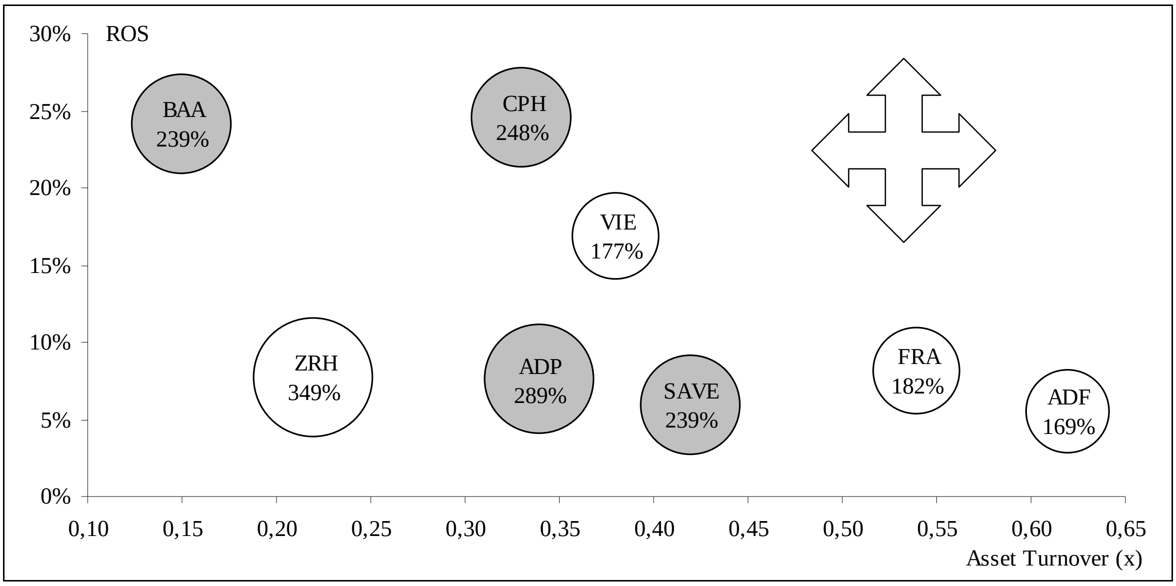
ROS (Return on Sales)	Net Income over Total Revenue
Total Asset Turnover	Total Revenue over Total Assets
Financial Leverage	Total Assets over Shareholders' Funds
	• The size of the bubble is determined by financial leverage • The position of the bubble is determined by ROS and asset turnover

Source: illustration derived from MSDW, 2000

Increasing ROS will be caused by an improved operating margin as a result of revenue enhancement and/or a reduction in operating costs, while a growth in costs exceeding the growth in revenues will result in the contrary. Revenue growth exceeding investment will accelerate asset turnover and vice versa. The magnitude of financial leverage is based on the respective capital structure in terms of gearing of the balance sheet. This is related – amongst other things – to debt capacity and credit standing and the value creating margin between the return on assets and the cost of debt. (For a topical illustration of the latter see e.g. Standard & Poor's, 2006).

Figure 4 displays the value profiles of the eight publicly quoted airport operators. The illustration is based on the above-described dimensions of total asset turnover (x-axis), ROS (y-axis) and financial leverage (represented by the size of the bubbles). The positioning within this framework is determined by the respective three-year averages for the fiscal years (FYs) 2004 - 2006. Those entities which were only recently listed at a stock exchange (ADP, SAVE) or taken over (BAA, CPH) are shaded.

Figure 4 - Value Profile of Sample Airports (Average FYs 2004-2006)



This graph illustrates the distinct positions of the eight sample airports within the above-described framework. The performance and thus value differs considerably in terms of operating efficiency as represented by the return on total revenue, total asset turnover, and capital structure as reflected by financial leverage. Furthermore, there appears to be a significant difference between companies recently listed or taken over and those, which already went public before the period under consideration – specifically regarding financial leverage.

The economic significance of increased asset turnover and capital productivity in terms of traffic throughput over productive assets is striking. In case investment grows faster than revenue, asset turnover will deteriorate, with an immediate effect on the return generated by the airport's assets. Investment in traffic growth and possibly additional commercial facilities must be profitable, otherwise it may not be rewarded by the investor.

Maximizing capacity utilisation appears to be the formula for success in the airport business. This is especially true nowadays, when market conditions demand decreases of aeronautical charges and the previously familiar ever-increasing retail spend per passenger has slowed down considerably. 'Sweating' the assets includes efficient management of traffic flows and optimal allocation of capital, finally maximizing the effectiveness of fixed assets investment, return rates and shareholder value (see also Feldman, 2007).

4.2 CORRELATION ANALYSIS OF KEY PERFORMANCE INDICATORS AND MARKET MULTIPLES

In order to explore the relevance of the identified key performance indicators regarding the valuation of airports correlation analysis has been conducted. Although this does not establish cause-effect relationships, it does attempt to determine whether a statistically significant relationship exists between two or more quantifiable variables. The three key performance indicators (KPIs) as well as various additional indicators of partial factor productivity (PFP) and financial ratio analysis (FRA) have been considered in this analysis and results are listed in Table 4. On a 95% confidence level only a few statistically valid relationships can be established: ROS is significantly correlated to EBITDA margin, P/E-ratio and dividend yield. Turnover of total assets is correlated with EBITDA margin and P/E-ratio, whereas financial leverage is only related to EBITDA margin.

Detailing further for partial factor productivity indicators and financial ratios reveals a number of other significant relationships with regard to KPIs as well as the six market multiples. As far as profitability is concerned, there is a fit between net profit per WLU and return on assets (ROA), return on equity (ROE), the revenue/expenditure ratio (RevEx), return on sales (ROS), asset turnover, EBITDA margin, EV/EBIT, P/E-ratio and dividend yield. Revenue generation in terms of total revenue per WLU is related to ROE, EV/Sales, EBITDA margin and EV/EBITDA, while total revenue per currency unit of shareholders' funds correlates with RevEX, ROS, asset turn and P/E-ratio. Total cost per WLU or cost efficiency has a significant impact on ROE, RevEx, ROS, asset turn, EV/Sales and EBITDA margin.

Regarding debt and asset management, there appears to be a significant correlation between ROA, debt ratio, gearing (debt/equity ratio), net assets as percent of total assets, asset turnover, financial leverage and EBITDA margin. Capital productivity or asset utilisation (WLU/assets) is related to assets per WLU, assets per ATM, asset turnover, ROS and P/E-ratio. Asset turnover is also the only KPI which is influenced by airport size, while traffic volume in terms of WLUs is significantly correlated with net profit, market capitalisation and P/E-ratio.

Moreover, several valid relationships exist amongst the traditional multiples, to some extent due to the very definitions: share price is significantly related to EV/Sales and EBITDA margin; EV/Sales to EBITDA margin and EV/EBITDA and P/E-ratio to EV/EBITDA, EV/EBIT as well as dividend yield. Not a single valid relationship, however, appears to exist between market capitalisation and any of the market multiples, whereas share price is significantly correlated with (ROA, ROE) EV/Sales and EBITDA margin.

It is worthwhile noting that all three KPIs are significantly correlated to EBITDA margin but not with those multiples involving enterprise value: EV/Sales, EV/EBITDA and EV/EBIT, while EV is defined as market capitalisation (number of shares outstanding x share price) plus net debt. Although P/E-ratio is significantly correlated with ROS and asset turnover, share price appears to be the crucial factor in this equation. This is supported by the fact that not a single valid

Table 4 - Correlation Results: Total Sample

	WLU	ROA	ROE	RevEx	Debt Ratio	Gearing	ROS	Asset Turn	Fin. Lever.	EV/ Sales	EBITDA Margin	EV/ EBITDA	EV/ EBIT	P/E-Ratio	Div. Yield
PAX	++	-	-	+	-	-	+	+	-	-	-	-	-	+	-
Cargo	++	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WLU	n/a	-	-	-	-	-	-	+	-	-	-	-	-	+	-
ATM	++	-	-	+	-	-	+	+	-	-	-	-	-	+	-
Net Profit	++	-	-	+	-	-	+	+	-	-	-	-	-	+	-
Profit/WLU	+	+	+	++	-	-	++	+	-	-	+	-	+	++	++
Tot. Revenue	++	-	-	-	-	-	-	-	-	-	-	-	-	+	-
T.Rev./WLU	-	-	+	-	-	-	-	-	-	++	+	+	-	-	-
Rev./S.Funds	-	-	-	+	-	-	+	++	-	-	-	-	-	+	-
Tot. Cost	++	-	-	-	-	-	-	-	-	-	-	-	-	+	-
T.Cost/WLU	-	-	+	+	-	-	+	+	-	++	++	-	-	-	-
Shareh. Funds	++	-	-	+	-	-	+	+	-	-	-	-	-	-	-
Total Assets	++	-	-	+	-	-	+	+	-	-	-	-	-	-	-
Ass.Utilisation	+	-	-	-	+	-	-	++	-	-	-	-	-	+	-
Ass./WLU	+	-	-	+	-	-	+	++	-	-	-	-	-	+	-
Ass./ATM	+	-	-	+	-	-	+	++	-	-	-	-	-	+	-
Asset Turnover	+	-	-	+	+	+	+	n/a	+	-	+	-	-	+	-
RevEx	-	++	++	n/a	-	-	++	+	-	+	++	-	-	+	++
ROA	-	n/a	++	++	-	+	++	-	+	-	-	-	-	+	+
ROE	-	++	n/a	++	-	-	++	-	-	+	+	-	-	+	+
ROS	-	++	++	++	-	-	n/a	+	-	-	++	-	-	+	++
N.Assets/T.Ass.	-	-	-	-	++	++	-	+	++	+	+	-	-	-	-
Debt Ratio	-	-	-	-	n/a	++	-	+	++	+	+	-	-	-	-
Gearing	-	+	-	-	++	n/a	-	+	++	-	+	-	-	-	-
Fin. Leverage	-	+	-	-	++	++	-	+	n/a	-	+	-	-	-	-
Share Price	-	+	+	-	-	-	-	-	-	+	++	-	-	-	-
Mkt. Cap.	++	-	-	-	-	-	-	-	-	-	-	-	-	-	-
EV/Sales	-	-	+	+	+	-	-	-	-	n/a	+	+	-	-	-
EBITDA Mar.	-	-	+	++	+	+	++	+	+	+	n/a	-	-	-	-
EV/EBITDA	-	-	-	-	-	-	-	-	-	+	-	n/a	++	+	-
EV/EBIT	-	-	-	-	-	-	-	-	-	-	-	++	n/a	++	-
P/E-Ratio	+	+	+	+	-	-	+	+	-	-	-	+	++	n/a	+
Dividend Yield	-	+	+	+	-	-	++	-	-	-	-	-	-	+	n/a

Note: + statistically significant; ++ highly significant; - not significant

Table 5 - Correlation Results and Comparison of Significant Differences between Split Samples

	WLU		ROA		ROE		RevEx		Debt Ratio		Gearing		ROS		Asset Turn		Fin. Lever.		EV/ Sales		EBITDA Margin		EV/ EBITDA		EV/ EBIT		P/E- Ratio		Div. Yield	
	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2
PAX	++	++	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	+	-	-	-	+	-	-	-	+	-	-	-
Cargo	++	++	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-
WLU	n/a	n/a	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	+	-	-	-	+	-	-	-	-	-	-	-
ATM	++	++	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	+	-	-	-	+	-	+	-	+	-	-	-
Net Profit	++	++	-	-	-	-	-	+	-	-	-	-	-	+	-	++	-	-	+	-	-	-	+	-	-	-	+	-	-	-
Profit/WLU	-	-	+	-	++	-	++	++	-	-	-	-	++	++	-	++	-	-	-	-	-	+	-	-	+	-	+	+	+	+
Tot. Revenue	++	++	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	+	-	-	-	+	-	-	-	-	-	-	-
T.Rev./WLU	++	-	-	+	-	+	-	+	-	-	-	-	-	+	-	-	-	-	+	-	-	+	+	-	+	-	+	-	+	-
Rev./S.Funds	-	-	-	-	-	-	+	+	-	+	-	+	+	+	+	++	-	+	-	-	-	-	-	-	-	-	-	+	-	-
Tot. Cost	++	++	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	+	-	-	-	+	-	-	-	-	-	-	-
T.Cost/WLU	++	-	-	+	-	+	-	+	-	-	-	-	-	+	-	-	-	-	+	-	-	++	+	-	-	-	-	-	-	+
Shareh. Funds	++	++	-	-	-	-	-	-	-	-	-	-	-	-	-	++	-	-	+	-	-	-	+	-	-	-	+	-	-	-
Total Assets	++	++	-	-	-	-	-	-	-	-	-	-	-	-	-	++	-	-	+	-	-	-	+	-	-	-	+	-	-	-
Ass.Utilisation	-	+	-	-	-	-	-	-	+	-	+	-	-	-	++	+	+	-	-	+	-	-	+	-	-	-	+	-	-	-
Ass./WLU	-	+	-	-	-	-	-	-	+	-	+	-	-	-	++	+	+	-	-	-	+	-	-	-	-	-	-	-	-	-
Ass./ATM	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	++	-	-	-	-	-	-	+	-	-	-	+	-	-	-
Asset Turnover	-	+	-	-	-	-	-	+	+	-	+	-	-	+	n/a	n/a	+	-	-	-	+	-	-	-	-	-	-	+	-	-
RevEx	-	-	+	+	++	+	n/a	n/a	-	-	-	-	++	++	-	+	-	-	-	-	-	++	-	-	-	-	+	+	-	+
ROA	-	-	n/a	n/a	++	++	+	+	+	-	+	-	+	+	-	-	+	-	-	++	-	+	-	-	-	-	-	-	+	+
ROE	-	-	++	++	n/a	n/a	++	+	-	-	-	-	++	+	-	-	-	-	-	+	-	+	-	-	+	-	+	-	+	+
ROS	-	-	+	+	++	+	++	++	-	-	-	-	n/a	n/a	-	+	-	-	-	-	-	++	-	-	-	-	+	+	-	+
N.Assets/T.Ass.	-	-	+	-	-	-	-	-	++	++	++	++	-	-	+	-	++	++	-	-	+	-	-	-	-	-	-	-	-	-
Debt Ratio	-	-	+	-	-	-	-	-	n/a	n/a	++	++	-	-	+	-	++	++	-	-	+	-	-	-	-	-	-	-	-	-
Gearing	-	-	+	-	-	-	-	-	++	++	n/a	n/a	-	-	+	-	++	++	-	-	+	-	-	-	-	-	-	-	-	-
Fin. Leverage	-	-	+	-	-	-	-	-	++	++	++	++	-	-	+	-	n/a	n/a	-	-	+	-	-	-	-	-	-	-	-	-
Share Price	-	-	-	++	-	++	-	-	+	-	+	-	-	-	+	-	+	-	-	++	+	+	-	-	-	-	-	-	-	-
Mkt. Cap.	++	+	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	+	-	-	-	-	-	-	-	-	-	-	-
EV/Sales	+	-	-	++	-	+	-	-	-	-	-	-	-	-	-	-	-	-	n/a	n/a	-	+	+	-	+	-	-	-	+	+
EBITDA Mar.	-	-	-	+	-	+	-	++	+	-	+	-	-	++	+	-	+	-	-	+	n/a	n/a	-	-	-	-	-	-	-	+
EV/EBITDA	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	n/a	n/a	++	-	+	-	-	-
EV/EBIT	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	++	-	n/a	n/a	++	-	-	-
P/E-Ratio	-	-	-	-	+	-	+	+	-	-	-	-	+	+	-	+	-	-	-	-	-	-	+	-	++	-	n/a	n/a	+	+
Dividend Yield	-	-	+	+	+	+	-	+	-	-	-	-	-	+	-	-	-	-	+	+	-	+	-	-	-	-	+	+	n/a	n/a

Note: + statistically significant; ++ highly significant; - not significant; [grey box] significantly different; S1 = ADF, FRA, VIE, ZRH; S2 = ADP, BAA, CP relationship could be established between any of the three KPIs and share price as well as market capitalisation.

This may be due to the fact that ROS, asset turnover and financial leverage are based on the business fundamentals – or rooted in the 'airport value tree' – while share prices are affected by external factors and market expectations. In order to control the most important external factors exerting an impact on share price performance the total sample has been split into two. Subgroup 1 (S1) consists of ADF, FRA, VIE, ZRH, which were all floated on the stock market well before the period under consideration. Subgroup 2 (S2) comprising ADP, BAA, CPH and SAVE, on the other hand, has experienced important changes during this period: The initial public offering (IPO) of SAVE Group only took place in early 2005 while Macquarie seized majority control of CPH later that year, and ADP's IPO as well as Ferrovial's takeover of BAA did not happen before mid 2006.

The identical correlation analysis has been run for the two split samples, the results of which are summarised by Table 5. Although this analysis basically confirms the above-discussed findings, it reveals significant differences between the subgroups under scrutiny, most notably regarding market multiples: While there is no connection between ROS of subgroup 1 and EBITDA margin or dividend yield there appears to be a valid relation to split sample 2 in both cases. As opposed to subgroup 2, total asset turnover of split sample 1 appears to be significantly correlated to EBITDA margin, whereas the turnover of subgroup 2, in contrast, is related to P/E-ratio. Only one statistically significant correlation has been detected for financial leverage, regarding split sample 1 and EBITDA margin. In summary, the results reveal profound differences between the individual subgroups and the valid relationship between ROS and P/E-ratio established above for the total sample is the only one which remains significant for both subgroups.

Under the split samples design the total number of valid relations between financial ratios and indicators of partial factor productivity is higher in general and refers to subgroup 1 in the majority of cases regarding market multiples. While various statistically significant correlations appear to exist amongst market multiples themselves – again specifically in respect to split sample 1 comprising airport companies which had already been listed before the period under scrutiny – a considerable number of contradicting regression results confirms the distinct differences between the two subgroups.

It needs to be reiterated, however, that in the vast majority of cases no statistically significant correlation could be detected between KPIs derived from the 'airport value tree' and based on business fundamentals and conventional multiples accounting for external factors and market expectations. This holds true for the analysis of split samples as well, which can only control for some but not all external effects. Wherever the actual share price is involved, most notably regarding EV, the key value drivers comprising operating efficiency, capital productivity and capital structure appear to be the more accurate metric.

This alternative valuation approach is not prone to misleading effects resulting from the overall investment climate, IPOs, unfriendly takeover bids, share buyback programmes or sector revaluation. They all affect the market sentiment and dealings in securities and may drive prices as well as multiples not backed by the business, possibly leading to overheated markets. Therefore, airports should not be valued by traditional multiples exclusively, but also by alternative business-based key performance indicators, since market- (or price-) driven metrics do not adequately reflect the earning power, profitability, financial and assets position, and thus the true value of the company.

5. CONCLUSION AND OUTLOOK

It is essential to understand that airports are asset-backed businesses with long-term visibility of cost and revenue structures. This makes them attractive lending propositions for banks. As long as debt is cheaper than the return earned by the assets the funds are invested in, it is efficient to employ more capital in the business. What will ultimately determine successful management in this industry is the ability to phase capital allocation in such a way that it generates a maximum return. This requires project management as well as financial skills for a thorough phasing of major investment spending and an optimisation of the use of debt facilities and equity supply.

Although based on the same business model, not all airport earnings are created equal. Functional similarities mask profound operational and financial variations. For example, comparatively low operating efficiency can be made up for by relatively high asset turnover and financial leverage. The individual value profiles visualize the distinctive features of the sample airports with different intensity of the ultimate value drivers, basically plotting an aggregated scorecard of key investment criteria. This is the added value of this valuation approach, which neither traditional nor other valuation techniques can equally accomplish.

Regarding investments in airports, this translates into a fundamental set of decision criteria as, for example, outlined by Kerrie Mather, CEO of Macquarie Airports (Map), in a recent ACI-interview: 1. A general (traffic) growth potential, 2. commercial potential, 3. margin growth potential, 4. existing physical capacity to accommodate future growth, 5. a regulatory framework allowing for a clear focus on investment and commercial opportunities, and 6. an appropriate capital finance structure (Airport Business Communiqué, 2006; see also Booth, 2008). It is quite evident that these decision criteria basically reflect the key value drivers of the driver-based alternative valuation approach introduced above. These are operating efficiency, asset utilisation or capital productivity and capital structure, and are summarised by the key performance indicators return on sales, asset turnover and financial leverage in model terms (see also Feldman, 2007).

Airports should not be valued with a single multiple but with measures recognising the key features of success of their value tree. The key value drivers comprising operating efficiency, capital productivity and capital structure appear to be the more accurate metric than price-driven market multiples not backed by the business. The alternative valuation approach is not prone to overall stock market fluctuations or sector revaluation and effects resulting from IPOs, unfriendly takeover bids or corporate share buyback programmes. Therefore, airports should not be valued by conventional multiples exclusively, but also by 'alternative' business-based key performance indicators, since market-driven metrics do not adequately reflect the financial position and true value of the company.

This approach is also expected to be much more reliable in times of a series of financial sector earthquakes, which recently forced American International Group (AIG) to sell its 50% stake in London City Airport (LCY). Moreover, it will be very interesting to see how the current global credit crunch and the resulting overall economic climate may affect airport privatisations and acquisitions. Several airports have already delayed infrastructure expansion as the crisis bites.

But as long as the underlying business fundamentals in terms of key investment criteria remain basically intact, there may even arise some interesting projects for potential buyers; if they only can be financed, which will be very difficult if an investor needs to borrow funding from banks. BAA's intended sale of London Gatwick (LGW) accelerated by the provisional findings of the UK Competition Commission's (CC) August 2008 interim report could be an acid test in unstable markets.

Additional research is indispensable, however, in order to complete this alternative approach to airport valuation, as this first stage primarily focused on establishing a framework and methodology and examined relations between the key value drivers and traditional valuation multiples applied by the investor community. The second stage will broaden the empirical basis in terms of scope of data and period under consideration. Due to the small peer group of publicly quoted European airport company observations from FYs 2003 and 2007 will be added. The analysis of partial factor productivity and financial ratios shall be detailed further for traffic growth and mix in terms of international passengers on the one hand and aeronautical revenue and concession income on the other. Furthermore, an in-depth share price analysis will be conducted, taking the performance relative to the local market index into consideration and accounting for capital expenditure and the investment cycle of airports. Resulting changes of KPIs over time will be analysed. Based on the anticipated findings, modelling of the relationships between market-driven multiples and KPIs embodying the roots value creation shall be pursued. Finally, implications for managing the value of airports will be addressed.

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LIST OF ABBREVIATIONS

ACI	Airports Council International
ADF	AdF-Aeroporto di Firenze SpA
ADP	Aeroports de Paris Group, France
AIG	American International Group
ATM	Air Transport Movements
BAA	BAA plc Group, (now BAA ltd) UK
CC	Competition Commission
CEO	Chief Executive Officer
CEPS	Cash Earnings per Share
CPH	Copenhagen, Denmark
DCF	Discounted Cash Flow
EBIT	Earnings before Interest and Taxes or Operating Profit
EBITDA	Earnings before Interest, Taxes, Depreciation and Amortization
EPS	Earnings per Share
EUR / €	Euro (currency)
EV	Enterprise Value
EV/EBIT	Enterprise Value versus Earnings before Interest and Taxes
EV/EBITDA	Enterprise Value over Earnings before Depreciation, Interest and Taxes
EV/Sales	Enterprise Value to Sales (Revenue)
FCF	Free Cash Flow
FLR	Florence, Italy
FRA	Financial Ratio Analysis
FRA	Frankfurt, Germany
FY	Fiscal Year
GDP	Gross Domestic Product
IATA	International Air Transport Association
IPO	Initial Public Offering
KPI	Key Performance Indicator
LCY	London City Airport
LGW	London Gatwick Airport
Mkt Cap	Market Capitalization

P/CEPS	Price / Cash Earnings per Share
P/CF	Price / Cash Flow
P/E	Price / Earnings
PAX	Passengers
PFP	Partial Factor Productivity
RevEx	Revenue / Expenditure Ratio
RAB	Regulated Asset Base
ROA	Return on Assets
ROE	Return on Equity / Shareholders' Funds
ROI	Return on Investment
ROS	Return on Sales / Total Revenue
SAVE	SAVE SpA Group
SBC	Swiss Bank Corporation
SBU	Strategic Business Unit
SOTP	Sum-of-the-Parts
S1	Subgroup 1
S2	Subgroup 2
t	Tonnes
UBS	Union/United Bank(s) of Switzerland
VCE	Venice, Italy
VIE	Vienna, Austria
WACC	Weighted Average Cost of Capital
WLU	Work Load Unit
WLU/Assets	Asset Utilisation
(x)	Times
ZRH	Zurich, Switzerland

The Perception of Time in Air transport – What a Delay is accepted by Air Travellers?

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ABSTRACT

This paper is about the perception of time by air travellers on business trips. Time is becoming a more relevant factor at airports due to all security checks. Furthermore, punctuality of airlines becomes an increasingly relevant factor due to overfilled airspaces around mega hubs. The question which arises is what level of delay is still accepted by air passengers on business trips without creating dissatisfaction with the delayed airline and if the accepted delay changes with frequency of air travels by business passengers. The sample includes 2834 air travellers which were interviewed before they were entering their flights at gates or in business lounges. The results reveal that a delay up to 30 minutes is acceptable in air travel. The more a passenger travels by plane the lower is the level of acceptance towards delays or the more punctuality becomes a basic factor and a power factor.

KEYWORDS: Aviation, air travellers, airline business travellers, time, punctuality.

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1. INTRODUCTION AND RESEARCH OBJECTIVE

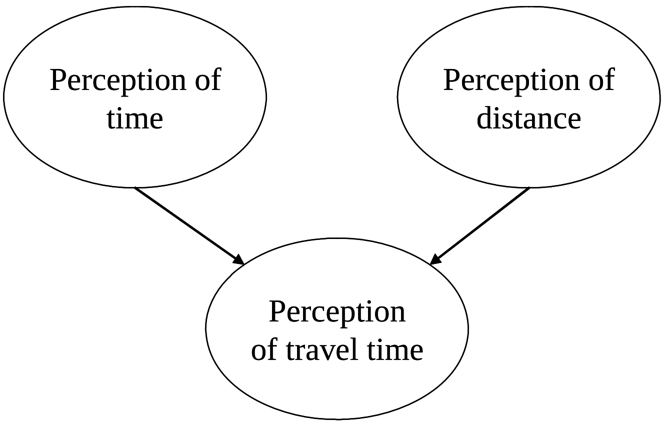
This paper is about the perception of time by air travellers on business trips. Time is becoming a more relevant factor at airports due to all security checks. Furthermore, punctuality of airlines becomes an increasingly relevant issue due to overfilled airspaces around mega hubs. Time is perceived as a sequence which is split into milliseconds. Intervals of time divide and examine the interdependence of objective, physical parameters from psychological aspects and psychological measurable factors. For an activity which needs a lot of thinking and uses intellectuality, time is perceived longer. Activities which do not need a lot of thinking make one perceive the time shorter. When travelling a specific route the first time, it is perceived more time consuming then if it is travelled regularly. The question which initiated this research was if total travel time is perceived differently if there is a delay versus if there is no delay of air travel services. Furthermore, the acceptance level of delays is of interest. The overall hypothesis which is going to be addressed in this study is: “The higher the punctuality the higher is the probability that the punctuality becomes a basic factor. In other words with an increasing delay perspective punctuality becomes an enthusiastic factor.” The hypothesis is addressed by using the Kano research and analysis method which aims at implicit rather than explicit results.

2. LITERATURE REVIEW

The topic of air travel delays at airports induces an understanding of the perception of travel time. Travel time perception depends on the perception of time and the perception of distance. For example a person travelling on a specific route from a to b the first time, might perceive the travel time longer then a person travelling on a specific rout for the 10th time. Time is perceived as a sequence or as intervals which are split in milliseconds. The perception of the presence, meaning the dissolution of the time flow in a cognitive wholeness lies about at three seconds (Laesser 2006). There exists a psychological phenomenon about the feeling of time. If an objective process needs a high level of intellectual action, the process is perceived as more time consuming. If an objective process needs less intellectual action, the process is perceived as less time consuming (Laesser 2006). Einstein (1916) defined in his research the relativity of time the interaction between matter on one hand, space and time on the other. In its core statement, gravitation leads back towards a geometric phenomenon in a curved 4-dimensional space-time. The body clock is different then the mental clock, because the mental clock is distensible. Consciously perceived movements slow the subjective perception of time down especially in case of unpleasant situations. Pleasant situations increase the speed of subjective time because of the concentration on the affair. Memorisation is exactly opposite (Klein 2006). In eventful times there is a lot of information saved in the mind and thus the time period feels long, whereas in the opposite non-eventful times time periods feel short in retrospect, due to a low amount of saved information in the brain. Therefore, the more information is saved over a time period, the longer this time period is perceived (Klein 2006).

The concept of the cognitive distance creates a time perception problem. Geographic distance, costs for the travel choice between origin and destination, the frequency a specific route or distance is travelled, attractivity of the route and finally the choice of the means of transport influence travel time perception.

Figure 1: Perception of travel time



Source: The authors

The weight of the travel time is substantially dependant on the rationale of a trip. Business trips are comparatively more time sensitive then leisure trips (Mackie et al. 2003; Hensher 1997, Laesser & Wittmer 2006). Furthermore, travel time clearly overrules other travel choice parameters in many cases (Mandel et al. 1997).

Habitualness is a further central determinant which can be derived from Fishbein and Aizen's (1975) planned behaviour approach. But different studies have indicated that habitualness is not necessarily resistant against changeable incentives like for example price or travel time of alternative suppliers. Thus, suppliers can only assume medium loyalty of their customers (Bamberg et al. 2003).

Furthermore, a large number of matters can restrict the freedom of choice and by this limit the objectivity of different choice parameters (Last & Manz 2003; Heggie 1977). Capability constraints, coupling constraints as well as legal constraints are such parameters. Such constraints play especially an important role in business travel, which is dominated by appointments. Especially equality respectively equivalence of costs and prices become an important factor of the service quality (Ben-Akiva et al. 2002). For example in the air traffic between Europe and Central Asia partly livelong transfer connections are taken into account to take a save trip with a save airline.

For this study travel time was defined as the time from the home to the destination, not only the time from airport to airport. The study focused on delays of airline, which result in longer waiting times for passengers at airports. The survey aimed at gathering data about the acceptability of delays at airports and the critical level of delay time.

3. METHODOLOGY AND DATA

The data were collected at Zurich airport during one week. Research was conducted at gates and in business lounges. Mainly business and economy class passengers were included in the study. Respondents had to answer some demographic questions (place of living, job, education, place of work, industry of work). Furthermore, information about their flights and flight behaviour was collected (reason for flying, flight intensity, choice of upstream transport means, development of flight frequencies, preferred flight times, etc.). To receive some implicit data, which is less influenced by actual distractions, some of the questions were asked by using the Kano method. Totally 3900 questionnaires were handed out to air passengers of whom 2834 were returned and resulted in a response rate of 72.65 %. The results do not intend to be fully representative, but rather provide an insight in to the behaviour of air passengers at Zurich airport (Laesser & Wittmer 2006).

The Kano model (Sauerwein et al. 1996) was chosen for the analysis because it values different functions and evaluates them by using the means-end-chains method. By that the relevant functions evolve. Furthermore, the specific method, using functional and dysfunctional questions filters deviations from the truth and enhances in implicit results. The long term object of this model is to improve customer satisfaction with regard to important product features in order to establish tenable competitive advantages. The model measures if the customer is satisfied by the level the requirements are fulfilled. This is generally measured by dividing into three major types of product requirements:

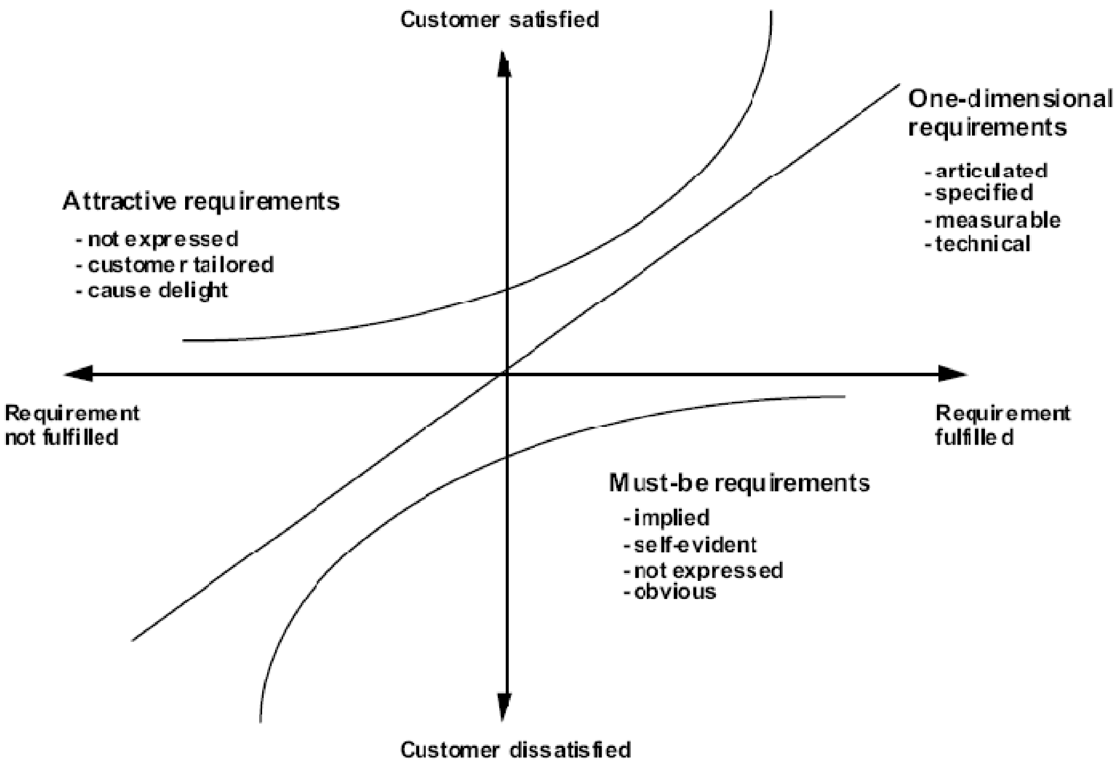
- First, must-be requirements (basic factors) must be fulfilled; otherwise the customer is extremely dissatisfied. They are taken for granted. Satisfaction is related digressively to the degree of performance respectively quantity related to quality. An increase of performance is solely able to prevent dissatisfaction, but not increase satisfaction.
- Second, with regard to one-dimensional requirements (power factors), customer satisfaction is proportional to the level of fulfilment. Satisfaction is linearly related to the degree of performance. An increase of performance of one unit produces an increase of satisfaction by one unit as well.
- Third, attractive requirements (enthusiasm factors) are product criteria which have the greatest influence on the satisfaction of a customer with a given product. Satisfaction is related progressively to the degree of performance concerning quantity and quality. An increase of performance increases satisfaction in an above average degree. A decrease generates no dissatisfaction though.

Figure 2 shows Kano's model of customer satisfaction, which was applied for the analysis of this research. It was the goal to find differences of passengers concerning delays according to the frequency of their air travel. For this purpose the data was grouped into five quintiles for a more differentiated analysis:

- Quintile 1: one or less business related flight per year (e.g. non flyers resp. leisure flyers) represented by 0.2 % of the sample.
- Quintile 2: two business related flights per year (e.g. non-frequent flyers) represented by 1.5 % of the sample.
- Quintile 3: 3-8 business related flights per year (e.g. non-frequent flyers) represented by 6.5 % of the sample.

- Quintile 4: 8-18 business related flights per year (e.g. frequent flyers) represented by 22.3 % of the sample.
- Quintile 5: more than 18 business related flights per year (e.g. frequent flyers) represented by 69.5 % of the sample.

Figure 2 - Kano's model of customer satisfaction



Source: Berger et al. 1993

Thus, the results are differentiated between the five quintiles of business air travels. The analyses are based on the fundamental hypothesis that the higher the punctuality, the higher is the probability that the punctuality becomes a basic factor. In other words with an increasing delay perspective punctuality becomes an enthusiastic factor with significant differences dependent on the number of business related flights. The rationale of the fundamental hypothesis lies in the fact that with an alternative perspective consisting of a 60 minute delay, a shorter or no delay evokes more enthusiasm then with a perspective of only a 15 minutes delay.

The data which are based on the Kano research method and thus split into basic, power and enthusiasm factors, were analysed to answer the fundamental hypothesis based on four hypothesis tests for each delay time perspective (15, 30, 45 and 60 minutes). For each a contingency analysis with chi-square independent test was conducted. The four hypothesis tests compare the punctuality and a 15, 30, 45 or 60 minutes delay with the quintiles of the number of yearly business related flights.

4. RESULTS AND DISCUSSION

The results are based on the hypothesis tests for the four different levels of delays. First, a comparison between punctuality and a 15 minutes delay according to the quintiles of the number of yearly business related flight is analysed (Table 1).

The result with respect to an expected 15 minutes delay shows significantly that a reduction of the delay can create satisfaction linearly. The more frequent a person flies the more it becomes a power factor creating satisfaction. For a significant number of travellers a reduction of an expected 15 minutes delay does not create any satisfaction, but an increase of the delay creates dissatisfaction and thus for them it is a basic factor.

Second, a comparison between punctuality and a 30 minutes delay according to the quintiles of the number of yearly business related flights is analysed (Table 2).

The result with respect to an expected 30 minutes delay indicates that the more frequent a person flies for business purposes, the more a reduction of the delay is perceived as a linear gain of satisfaction. Still for a significant number of travellers a reduction of an expected 30 minutes delay does not create any satisfaction, but rather dissatisfaction if an increase of the delay happens and thus for them it is a basic factor. Up to 30 minutes expected delay creates linear satisfaction with a reduction of the delay and dissatisfaction if the delay is increased and longer than expected.

Table 1 - Hypothesis test with regard to a 15 minutes delay

HYPOTHESIS:	The more often a person flies for business purposes per year, the more critical respectively problematic are potential delays in the flight offers.
METHOD:	Contingency analysis (cross tabulation) and Chi-Square independent test for quintiles of the number of yearly business related flights. Comparison of punctuality versus a delay of 15 minutes.
SAMPLING:	All cases
RESULT:	Quintile specific distribution of factor classification according to the Kano approach.

Anova:

X^2=92.063; Sig.=.000; CC=.211

↓Description (flights)→ **Quintile**	**1. Q (0.4)**	**2. Q (2)**	**3. Q (7.2)**	**4. Q (18)**	**5. Q (∞)**
Enthusiasm factor	7.7%	4.2%	1.6%	2.7%	0.8%
Power factor	47.9%	53.9%	63.3%	62.6%	67.2%
Basic factor	24.7%	27.5%	25.3%	21.0%	24.9%
Indifferent, questionable or contrary	19.7%	14.4%	9.7%	13.8%	7.1%

INTERPRETATION: Hypothesis confirmed.

Source: Own research

Table 2 - Hypothesis test with regard to a 30 minutes delay

HYPOTHESIS:	The more often a person flies for business purposes per year, the more critical respectively problematic are potential delays in the flight offers.
METHOD:	Contingency analysis (cross tabulation) and Chi-Square independent test for quintiles of the number of yearly business related flights. Comparison of punctuality versus a delay of 30 minutes.
SAMPLING:	All cases
RESULT:	Quintile specific distribution of factor classification according to the Kano approach.

Anova:

X^2=107.155; Sig.=.000; CC=.227

↓Description Quintile (flights)→	**1. Q (0.4)**	**2. Q (2)**	**3. Q (7.2)**	**4. Q (18)**	**5. Q (∞)**
Enthusiasm factor	11.2%	6.3%	3.8%	3.4%	2.6%
Power factor	44.5%	52.3%	60.9%	61.8%	65.9%
Basic factor	23.4%	26.3%	23.9%	20.5%	24.9%
Indifferent, questionable or contrary	20.9%	15.1%	11.5%	14.3%	6.6%

INTERPRETATION: Hypothesis confirmed.

Source: Own research

Third, a comparison between punctuality and a 45 minutes delay according to the quintiles of the number of yearly business related flights is analysed (Table 3).

Table 3 - Hypothesis test with regard to a 45 minutes delay

HYPOTHESIS:	The more often a person flies for business purposes per year, the more critical respectively problematic are potential delays in the flight offers.
METHOD:	Contingency analysis (cross tabulation) and Chi-Square independent test for quintiles of the number of yearly business related flights. Comparison of punctuality versus a delay of 45 minutes.
SAMPLING:	All cases
RESULT:	Quintile specific distribution of factor classification according to the Kano approach.

Anova:
X^2=125.330; Sig.=.000; CC=.244

↓Description Quintile (flights)→	**1. Q (0.4)**	**2. Q (2)**	**3. Q (7.2)**	**4. Q (18)**	**5. Q (∞)**
Enthusiasm factor	32.0%	23.5%	24.3%	19.1%	19.2%
Power factor	23.7%	34.9%	39.9%	45.9%	48.6%
Basic factor	12.8%	16.9%	13.7%	14.0%	19.7%
Indifferent, questionable or contrary	31.6%	24.7%	22.1%	21.0%	12.6%

INTERPRETATION: Hypothesis confirmed.

Source: Own research

The result with respect to an expected 45 minutes delay shows that it is still a power factor, meaning that there is a linear relation between a reduction of the delay and the satisfaction generated. For frequent business travellers it is rather a linear power factor, whereas for non-frequent travellers an underbidding of an expected 45 minutes delay leads to a more then linear satisfaction gain being an enthusiasm factor for them.

Fourth, a comparison between punctuality and a 60 minutes delay according to the quintiles of the number of yearly business related flights is analysed (Table 4). The result shows significantly that if a 60 minutes delay is expected, less delay creates more than average satisfaction whereas a higher than 60 minutes delay does not generate a lot more dissatisfaction. Thus, a reduction of delay, if a 60 minutes delay is expected creates an above average satisfaction.

Table 4 - Hypothesis test with regard to a 60 minutes delay

HYPOTHESIS:	The more often a person flies for business purposes per year, the more critical respectively problematic are potential delays in the flight offers.
METHOD:	Contingency analysis (cross tabulation) and Chi-Square independent test for quintiles of the number of yearly business related flights. Comparison of punctuality versus a delay of 60 minutes.
SAMPLING:	All cases
RESULT:	Quintile specific distribution of factor classification according to the Kano approach.

Anova:

X^2=78.990; Sig.=.000; CC=.196

↓Description Quintile (flights)→	**1. Q (0.4)**	**2. Q (2)**	**3. Q (7.2)**	**4. Q (18)**	**5. Q (∞)**
Enthusiasm factor	43.1%	47.1%	48.8%	51.1%	45.7%
Power factor	8.3%	7.2%	11.5%	12.0%	19.9%
Basic factor	2.2%	6.5%	4.3%	4.3%	6.0%
Indifferent, questionable or contrary	46.6%	39.2%	35.4%	32.5%	28.4%

INTERPRETATION: Hypothesis confirmed.

Source: Own research

Practically this means that if expectations are set towards high delays, it is easier to create customer satisfaction by having less delay and there is no great impact on satisfaction by more delay. Thus, if airlines are known for their delay, they can create satisfaction more easily then if they are expected for being on time.

Overall the results of the four tests confirm that a perspective of a small systematic delay leads punctuality to be perceived as a basic factor, meaning that a reduction of delay can only prevent dissatisfaction. The perspective of a big delay leads punctuality to be perceived more and more as an enthusiasm factor, meaning that a decrease in the expected delay increases satisfaction more than linear.

In practice if airlines or airports announce a delay of an air connection especially a departure, it can influence the level of satisfaction of its passengers by the communication principle. If a delayed flight is expected to leave 45 minutes late, satisfaction can be created if passengers are told that the flight is expected to leave in 60 minutes at first and to a later stage in a further announcement passengers can be told, that the delay has been reduced by 15 minutes. Dissatisfaction is created, if passengers are told the plane is expected to leave in 30 minutes and in a second announcement a correction with an additional 15 minutes has to be communicated, as a further 15 minutes delay can in the best case only prevent dissatisfaction.

5. SUMMARY AND CONCLUSIONS

Travel time perception plays an important role in case of satisfaction or dissatisfaction in connection with delays. By specific communication strategies or attractions at the airports, delay can be perceived more or less negatively or even positively.

The research in this paper has identified different time perceptions of air travellers on business trips when it comes to delays related to the expected delay. Travel time is an important issue for frequent and non-frequent travellers and includes the whole trip from home to the end destination. Generally, a delay of 15 - 30 minutes is taken into account. Delays of more then thirty minutes are seen as bad and negatively influence the satisfaction level of business air travellers. Interestingly, the more frequent a passenger is travelling; a reduction of expected delays up to thirty minutes creates satisfaction. It cannot be generalised though, that delays up to thirty minutes create satisfaction. For a significant number of respondents a reduction of the expected delay just prevents from dissatisfaction. If delays of more than thirty minutes up to sixty minutes are expected, a reduction of the delay results in a linear and sometimes even more than average increase of satisfaction compared to the amount of time of reduction.

For airlines and airports it can be concluded that time delays should rather be announced as longer time delays than expected and then if the plane is earlier reduced the exact delay. By this, less dissatisfaction arises; even a chance of creating satisfaction is given. By announcing a delay and later on postpone a departure again by another delay creates dissatisfaction. Hence, by introducing an ingenious delay communication procedure, passengers might become more satisfied with their air travel.

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Applying Functional Analysis to Study the Airline Pilot's Perspective on Human-Human Interactions during Flight Operation

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ABSTRACT

The objective of the study is to understand the cooperation building process within Human-Human Interaction (HHI) during Collaborative Decision Making (CDM) in a distributed, multiple-objective decision making environment. It is based upon functional HHI analysis within typical CDM flight operation situations where the flight operation includes the inbound, turn-round, and outbound phases of the flight. A survey was undertaken which sought to identify aircraft pilots' perspective on cooperation with other operators during various flight situations. In this study, different situations are compared and characterized by: (1) a synchronous interaction mode, where all participating operators interact with each other at the same time, and (2) an asynchronous interaction mode, where the participating operators interact with each other at different times. Task and decision-making for all situations is distributed between operators. The aircraft pilot's perspective and their information requirements during these flight situations are used to identify critical information processing during CDM.

KEYWORDS: Air traffic management, asynchronous distributed collaboration, collaborative decision making, cooperation, human-human interaction

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1. INTRODUCTION

Updated from earlier projects in the United States, the European CDM approach was introduced during field trials at selected European airports with the aim of achieving cooperation at *planning level* via information sharing and common situational awareness (CSA). However, from aircraft pilots' perspective on current air traffic operation, many problems encountered with CDM arise from human-human interactions (HHI) at *action level*; whereby HHI at *action level* refers to interactions with a shorter time span and less abstraction than HHI at *planning level* (Hoc, 2000). Further problems for CDM operation are conditioned on the specific situation of decision-making in an *asynchronous*, *distributed* collaboration environment as can be found in ATM operational decision-making. Operators, like aircraft pilots, ground handlers etc, communicate with the operational centres of the airlines, ATC, and the airport through speech (e.g. via phone or radio) or written text (e.g. via ACARS). This paper will seek to understand how the airport CDM information-sharing process is influenced by the following variables:

- Interaction Mode (synchronous versus asynchronous)
- Information Distribution (homogeneous versus heterogeneous)

Even little understanding of *how* operators think during CDM exists (Terveeen, 1995), an analysis of HHI within CDM via the perspective of a single operator (aircraft pilots) is used in order to cope with the still very inadequate mechanisms of collaborative problem-solving during operators' decision-making. According to Ferber (Ferber, 1995), HHI situations can be classified as antagonistic, cooperative, or indifferent depending on the *aims, resources*, and *abilities,* held by each participating operator. This classification is applied in order to understand micro-level cognitive aspects of HHI in CDM flight operation situations. The advantage of using aircraft pilots as a reference group is that they are not penalised for failing to meet punctuality targets. The existing method of *delay assignment* seeks to identify the cause of delay and assign the responsibility to a single operator via defined delay codes. Usually each operator tries to avoid assignment of a delay due to the penalties than can be expected.

In this paper, prototypical HHI situations between all operators involved in flight and turn-round operation are introduced. They all take place in a distributed collaboration environment, where coordination of processes is necessary. Processes include parking, ramp-side, land-side, and special ground handling processes. Within these situations, cooperative HHIs are mandatory: pilots have to coordinate processes with other operators like representatives of the ground handling companies, airport, airline, air traffic control, and Central Flow Management Unit. Cooperation and decision-making is distributed between pilots and other operators. Decision-making at the start of the turn-round process is designed to facilitate the processing of the aircraft (e.g. boarding, de-boarding, refuelling, cleaning..) - this is the responsibility of pilots. Other operators will make decisions in order to coordinate and execute various processes designed to achieve a successful and punctual turnaround. These operators will often need to cooperate with each other. While any delayed process start can result in an overall delay of the subsequent flight, coordination of a standard turn-round (defined as a reference model) is usually predetermined.

During a normal turn-round operation, *interactions* between pilots and other operators can be *synchronous* or *asynchronous*. Coordination of actions takes place via predetermined key events (*milestones*), organized as a sequence of interactions between operators within the airport operations centre; if a non-standard situation like aircraft change, technical repair, adverse weather operation, etc. occurs, ad hoc coordination of all necessary events *via face-to-face* communication between pilots and ramp agents or via radio/ phone between pilots and other operators coordinating from airport operation centre takes place. The *milestone approach* used for CDM, includes *all* events which are necessary for an uninterrupted turn-round process, whereby some key events take place already far ahead of the turn-round itself. Information distribution during turn-round is mainly *heterogeneous* between participating operators on *action* and *planning* level caused by the information dynamics in the highly dynamic environment of the turn-round operation and the varying tasks in the different domains themselves. However, in order to cope with the usually limited time span for turn-round operation, CDM targets *homogeneous* information processing achieved through a CSA between all participating operators and to avoid departure delay caused by non-standard operation.

Other proposed situations concern the *inbound* or *outbound* phases of the flight, starting from aircraft leaving the parking position until reaching parking position at the destination. Coordination here is also necessary for departure and arrival sequencing with other aircraft, usage of taxiways, airways and airspace/ sectors. It is the pilot's responsibility to execute the flight according defined rules under consideration of highest degree of safety possible. The other operator involved for coordination of traffic during flight is air traffic control (ATC). ATC seek to ensure that there are safe separation distances between aircraft and they manage air traffic flow by issuing clearances to pilots. The different level of control between pilots and other operators like ATC in this situation is that ATC has authority about assigning the airspace in the form of clearances to the pilots and again this depends on the cooperation of pilots in adhering to these clearances. Decision-making is shared between pilots and ATC within their domains relative to the situational need, but has to be executed under previously-mentioned safety constraints. Other operators like the Airline Company or Central Flow Management Unit (CFMU) are only marginally involved in decision-making during the flight operation phase.

During the inbound phase of the flight, interactions between pilots and air traffic control are *synchronous* established via radio communication; however interactions between air traffic controllers of different sectors can also be *asynchronous*, resulting in a non-coordinated flight through different sectors. Interactions between pilots and other operators are usually *asynchronous* and *distributed*. Information interactions for the issue of clearances concerning airspace and routing are always homogeneous, while information distribution for *reasons* of the deviations from previous clearances can be homogeneous or heterogeneous.

During the turn-round phase of a flight, the complexities of the operation result in high dynamic information content. While some information like variations in flight progress occur on a standard basis and changes are automatically accessible to all participating operators via data link transmission, non-standard information like operational changes or technical issues, are transferred by non-synchronized interactions and need to be manually transmitted between operators. This requires cooperation among operators' interactions and defines the need to achieve a common situational awareness among all operators.

The resulting objectives for this paper study are:

- To understand the cooperation building processes of the HHI during day-to-day flight operation which are necessary in the context of a distributed collaborative decision-making environment across objective functions of all operators.
- To identify the information sharing components which should be employed to optimize the CDM concept in ATM typical standard & non-standard flight situations.
- To understand how agents can support humans in achieving collaborative knowledge during distributed collaborative problem-solving.

2. THEORETICAL BACKGROUND

In our context of flight operation, HHI are seen as dynamic relations between pilots and other operators via a number of mutual actions. Each action by one operator has consequences which influence the behaviour of others. A series of actions form events and a number of events form the turn-round or flight situation (e.g. ATC assigns a parking position for the aircraft to the pilots (event) via mutual communication usually by two-way radio communication (HHI) in a turn-round situation). Ferber (1995) defines interaction situations as *a number of behavioural patterns which evolves from a group of agents, who have to act in order to reach their targets and thereby have to regard their more or less limited resources and capabilities*. By using this definition, interaction situations can be described and analysed, because it defines abstract categories like cooperation, antagonism, and indifference via differentiation of observed key commonalities and different interaction situations. The relevant components for classification of interaction situations are the aims and intentions of the different agents, the relations of the agents to available resources, and abilities of the agents in regard to their assigned task. These criteria are used to define different types of interaction situations as shown in Table 1.

Each type of interaction situation has its own category. In an *Independence* situation, no interaction takes place and sufficient resources and abilities allow a coexistence of operators without any constraint. This situation has no relevance for ATM at congested airports. A *Simple Working Together situation* defines a collaboration situation which does not require coordination between operators, while a *Blockade, Coordinated Collaboration, Pure Individual/Collective Competition* and *Individual/Collective Resource Conflict* are situations which are expected to dominate in our contemplated HHI situations. These situations require coordination between operators and, depending on resources, aims, and abilities, can result in cooperative or antagonistic behaviour.

During flight operation situations, HHI are usually not binding relations between involved actors and no mutual influence is exercised between pilots and other operators; therefore social components of the interactions are not contemplated. According Hoc (Hoc, 1998, 2001), cooperation can exist within various levels in terms of distance from the action itself: A cognitive architecture of cooperation model classifies cooperation in abstraction level and process time depending on the proximity to the action itself is shown in Figure 1.

Table 1 - Classification of interaction situations

Aims/ Interests	Ressources	Abilities	Type of Situation	Category
compatible	sufficient	sufficient	Independence	Indifference
compatible	sufficient	insufficient	Simple working together	Indifference
compatible	insufficient	sufficient	Blockade	Cooperation
compatible	insufficient	insufficient	Coordinated collaboration	Cooperation
incompatible	sufficient	sufficient	Pure individual competition	Cooperation
incompatible	sufficient	insufficient	Pure individual competition	Antagonism
incompatible	insufficient	sufficient	Individual resource conflict	Antagonism
incompatible	insufficient	insufficient	Collective resource conflict	Antagonism

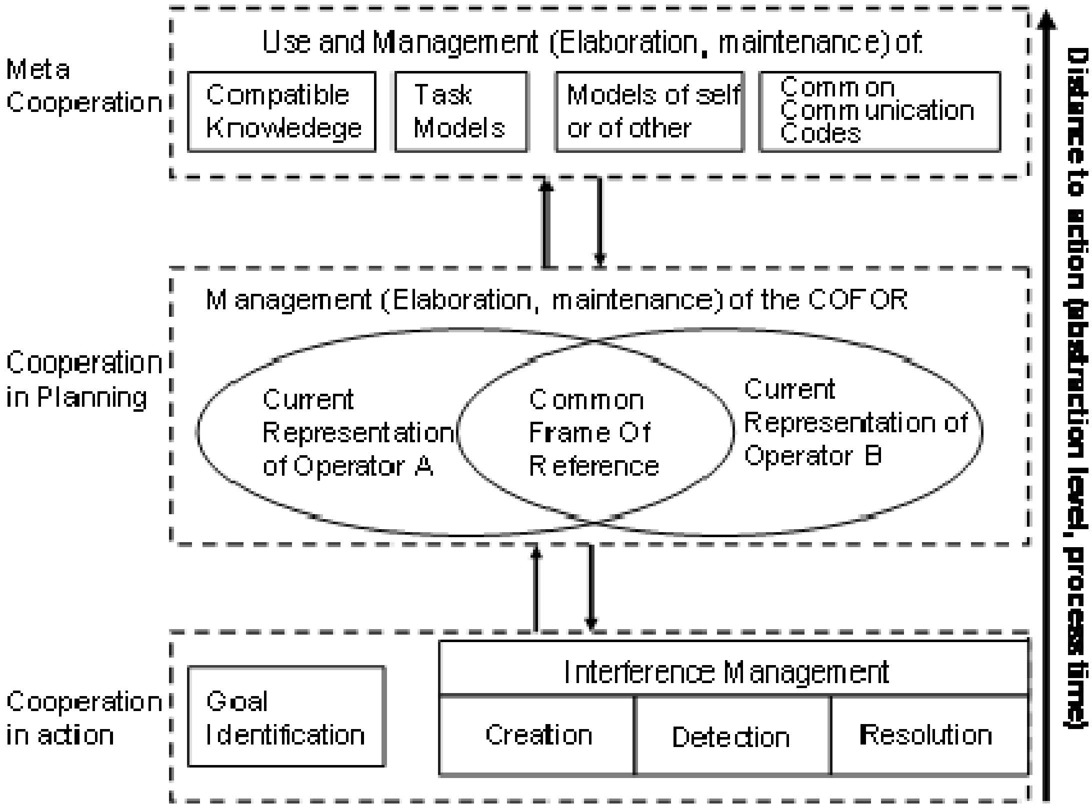
Source: Ferber (1995)

For the study of HHI situations, the focus is on cooperation (or antagonism, if relevant) at action level. At *action level*, the operators perform operational activities related to their individual goals, resources, and abilities. Hoc (Hoc et al., 1998) has defined four types of activities at action execution level which are interference creation (e.g. mutual control), interference detection, interference resolution, and goal identification (goal identification also embodies identification of other operators goals). Cooperation at action level has short-term implications for the activity, as opposed to the more abstract type of cooperation at planning level. Interference creation relates to the deliberate creation of interactions; interference detection to the ability of detecting interferences, especially in non-deliberate interference situations; and interference resolution to the actual interaction in order to find a cooperative solution. Mutual domain knowledge is the basis for other operators' goal identification, to facilitate operator's own task, the other's task, or the common task.

At planning level, operators work to understand the situation by generating schematic representations that are organized hierarchically and used as an activity guide (Hoc, 1998). Schematic representations include the concept of situation awareness (Salas et al., 1995), and operators' goals, plans, and meta-knowledge (Hoc, 1998); therefore the current approach to CDM operation in ATM is seen as an approach towards cooperation at planning level. De

Terssac and Chabaud (1990) use the term COFOR (Common frame of Reference) as a mental structure playing a functional role in cooperation and as a shared representation of the situation between operators likely to improve their mutual understanding (Carlier et al., 2002). The top most level in Hoc's model, the meta-cooperation, is level developed from knowledge of the other two levels. This dimension is not contemplated in the study.

Figure 1 - Processing architecture of cooperation



Source: Hoc (2000)

Piaget (1965) distinguishes between cooperation seen from structural (e.g. network organization) or functional perspectives which covers cooperation as activities performed by individuals within a team in real time. Two minimal conditions must be met in cooperative situations: (1) each actor strives towards goals and can interfere with other actors on goals, resources, and procedures. (2) Each actor tries to manage interference to facilitate individual activities or a common task. Both conditions are not necessarily symmetric, because goal orientation or interference management depend on individual behaviour or time constraints.

Hoc (2001) argues that current air traffic management (ATM) is more concerned with operators' plans, goals, or role allocation instead of common situational awareness. But Lee (2005) lists situational awareness, responsibilities and control, time, workload, and safety constraints as key factors driving collaborative behaviour in air traffic control operations. To have proper awareness of the situation, a controller and/or pilot needs to initiate or be informed of actions taken by other operators. However, time pressures brought on by the need to meet various operational and safety-related targets will have an adverse effect on communication, cooperation and the extent of common situational awareness.

Share of responsibility and control are often different but determined through situation (e.g. air traffic controllers issue clearances which have to be executed by pilots). Nevertheless, the more assistance, the more anticipative the mode of operation in controllers and the easier the human-human cooperation (Hoc, 1998). Collaborative Decision Making means applying principles of individual decision making on groups, whereby groups are established with the aim to show collectively a specific behaviour (Jennings et al., 2001). This implies that cooperation of participating individuals should be beneficial for CDM operation, also in air transport management. But how does cooperative work look like on day-to-day basis? Cooperation has a wide variety of connotations in everyday usage (Schmidt 1994). Do people only cooperate, if they are mutually dependant in their work or is mutual dependency sufficient for cooperation to emerge? In the context of CDM operation, confrontation and the combination of different perspectives of cooperation is an issue: how is the pilot's perspective embedded in the current CDM approach? For Schmidt (1994), the multifarious nature of the task can be matched by application of multiple perspectives on a given problem via articulation of the perspectives and transforming / translating information of different domains.

The challenge of CDM operation in ATM is the unique cognitive mechanisms in a distributed and highly dynamic environment as can be found in flight operations. Similar situations can be found in military teams with asynchronous, distributed teams for mission planning and mission execution, but in general it is a relatively new area (Keisler et al., 2002). Other domains which have related aspects to asynchronous distributed collaboration are not contemplated. Warner (Warner et al., 2002, 2003) describes the major factors impacting collaboration which are the collaborative problem environment, operational tasks, collaborative situation parameters, and team types (Table 2).

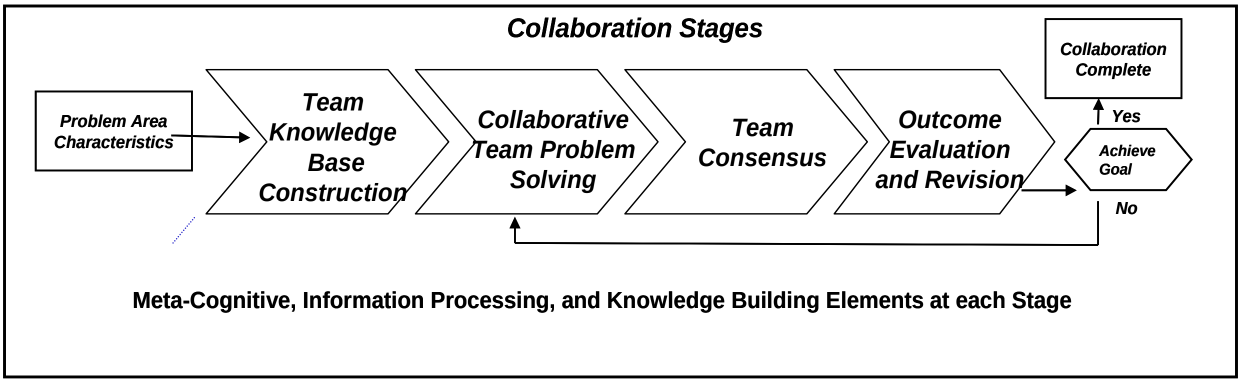
His structural model of collaboration focuses on team decision-making, course of action selection, developing shared understanding, and intelligence analysis. Thereby, various parameters can influence the collaboration performance (Warner et al., 2006). The collaborative decision parameters can be adapted to fit the specific environment of CDM in other domains using the respective characteristics under operational tasks, collaborative situation parameters, and team types. Werner's structural model of team collaboration uses the minimum number of unique stages identified in team collaboration literature and the results from a collaboration and knowledge management workshop (Figure 2).

Table 2 - Problem area characteristics for collaboration

Collaborative Situation Parameters	Team Types
• Time pressure • Information/knowledge • Time pressure • Information/ knowledge • Uncertainty • Dynamic information • Cognitive overload • Complexity • Human agent	• Asynchronous • Distributed • Culturally diverse • Heterogeneous knowledge • Unique roles • Command

Source: Warner (2003)

Figure 2 - Structural model of team collaboration



Source: Warner (2003)

This structural model is based on the meta-cognitive processes of an information processing and communication approach. For Davidsen (Schmidt, 1994), meta-cognition is the knowledge of one's own cognitive processes in explaining how human cognitive processes are used for problem solving. According Werner, there is 'no generally recognized unified theory of human cognition'. By implementing Ferber's component approach, a micro level cooperation perspective is applied into the structural collaboration model. This approach allows adapting the structural model of team collaboration to a distributed decision-making environment under consideration of decision-making across objective functions (e.g. like Airport CDM).

3. METHODOLOGY

A methodological approach is used for the analysis of the cooperative mechanisms within HHI. First, all flight & turn-round situations which are seen as critical for CDM operation in terms of punctuality are determined via in-depth interviews with senior commanders of different airlines. All situations were decomposed into elementary activities and thereafter grouped into event classes. The classes within turn-round situations include the subclasses gate assignment, standard ramp services, standard land-side services, and non-standard turn-round services. Some event classes have only one possible event as problem cause.

For each event class, the collaboration stages analogous Werner's structural model were identified. To understand how participating operators think during each stage, a self-administered questionnaire was developed which aims at getting knowledge about information processing (meta-cognitive level) and interaction components (micro-cognitive level) between participating CDM operators within distributed collaborative decision-making. All questions were designed from the perspective of the airline pilots as members of distributed airport collaborative decision making (perspectives of other operators could also usefully be researched). As reported by airline pilots, all event classes have critical elements concerning collaboration. Therefore, the questions are designed to find the most problematic stage within the collaboration process.

4. DEMONSTRATION

Critical Human-Human Interactions

30 pilots from different airlines were asked during unstructured questioning to name processes with problems in regard to HHI during day-to-day flight and turn-round operation. From all mentioned examples, five critical situations were defined and *Table 3* provides an overview of the situations as reported by the airline pilots.

Table 3 - Critical information sharing situations

TURN-ROUND	COOPERATION	COOPERATIVE COMPONENT	FREQUENCY	RELEVANCE
Parking Stand Availability	Y/N	Aims/Resources/ Abilities	Daily/Weekly /Monthly	Delay Avoidable Yes/No
Operational Information to Cockpit	Y/N	Aims/Resources/ Abilities	Daily/Weekly /Monthly	Delay Avoidable Yes/No
Operational Information from Cockpit	Y/N	Aims/Resources/ Abilities	Daily/Weekly /Monthly	Delay Avoidable Yes/No
ATC Information Provision	Y/N	Aims/ Resources/ Abilities	Daily/Weekly /Monthly	Delay Avoidable Yes/No
Ramp/Terminal Service Problem	Y/N	Aims/ Resources/ Abilities	Daily/Weekly /Monthly	Delay Avoidable Yes/No

Source: Own Data (2007)

The underlying situations do not have any statistical relevance in terms of importance or frequency; the aim was to find a wide spectrum of possibly critical HHI. In particular, the identified critical situations at turn-round are:

- After landing, parking stand is still occupied
- During turn-round, delay of *rampside* ground handling process, e.g. baggage loading, catering, cleaning
- During turn-round, delay of *landside* (inside the terminal) ground handling process, i.e. check-in, security, boarding
- During turn-round, delay of special (non standard) ground handling process, i.e. wheelchair boarding, aircraft change
- During turn-round, departure delay or runway change from ATC because of high traffic density

- During turn-round, missing information about operational changes at destination
- During turn-round, pilot's proposal of operational changes which were not considered as proposed

For each situation, pilots were asked to rate the cooperative behaviour of other operators:

- How or when information is given by other operators
- How much delay resulted from non-cooperative behaviour
- How important is information sharing for pilots in relation to the critical situation
- Which interaction component could be the reason for non-cooperation, if relevant: aims, resources, or abilities
- Would delay be avoidable with better information sharing, if relevant

Questionnaire administration & airlines involved

The survey entailed cockpit crews from a range of airlines that had agreed to to participate. The questionnaire was administered on-line at the EUROCONTROL Experimental Centre server. All cockpit crew members were addressed directly by mail and additionally by face-to-face questioning. The questionnaire was available in the English and German languages.

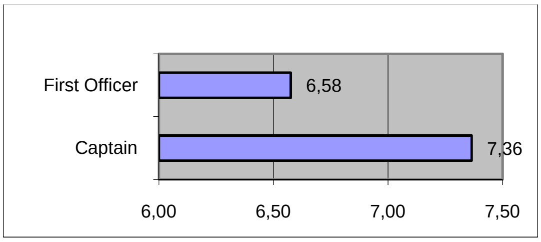
5. RESULTS

Pilots' General Information

196 pilots participated in the survey representing Austrian Airlines (n=2), Air Berlin (n=16), Air France (n=9), Austrian (n=2), Easy Jet (n=1), Lufthansa (n=77), and Transavia (n=1). Captains made up 44.6% of the sample with the remaining 55.4% consisting of first officers. The survey was accessible via internet for a period of three months. The number of participating pilots flying into secondary airports was negligible.

The experience from participating First Officers ranged between 1 and 8 years (mean 6.58; σ = 4.40) and Captains from 1 to 20 years (mean 7.37; σ = 5. 87) years of experience as pilots. The average years of the First Officers includes the experience which Captains reported before upgrading.

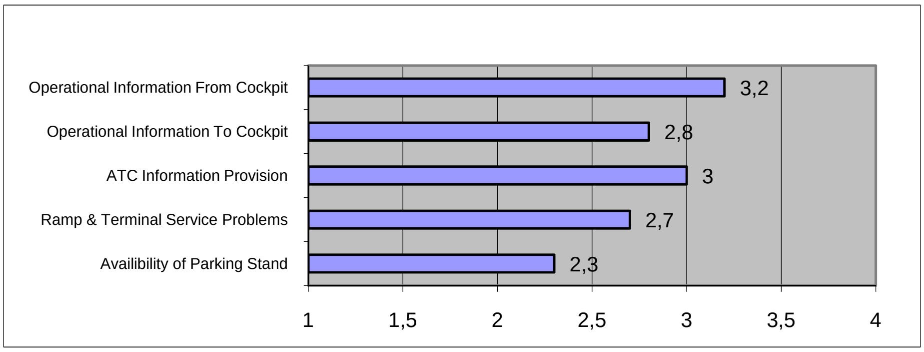
Figure 3 - Mean pilots experience in years



Pilots' Information Requirements

In this section, the results concerning pilots' information requirements will be shown as a function of '*delays avoidable*' as reported by pilots. Table 5 shows the mean values that received high ratings of the five proposed turn-round situations:

Figure 4 - Mean rating 'delays avoidable'



Pilots assigned highest ratings to the statement 'need to take information into account which was proposed by pilots', where pilots see least options to avoid delays through 'timely notification of problems with parking stand assignment'. However, the initial hypothesis that 'reliable provision of operational information to the pilots is correlated with *'delays avoidable'* did not show statistical significance.

Pilots were asked to report events they experienced; however, most of the pilots used the *proposed* situations in the questionnaire which were verified as 'critical' during focus group meetings. Table 4 shows reported frequency of the five proposed turn-round situations of all participating pilots and reported turn-round events as frequency in percentage terms.

Table 4: Turn-round events as reported by pilots

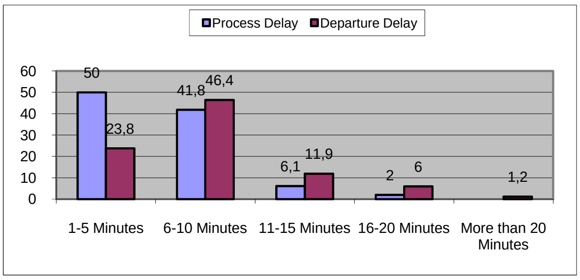
Turn-Round Problem	Reported Situation Frequency in %	Reported Event Frequency in %
SITUATION I: Availability of Parking Stand	95,1	95,1
SITUATION II: Baggage Loading/ Unloading	100	47,1
SITUATION II Ramp Transfer Bus (Passenger or Crew)	100	11,8
SITUATION II: Catering	100	1
SITUATION II: Cleaning	100	2,9
SITUATION II: Fueling	100	4,9
SITUATION II: Check-In	100	1
SITUATION II: Security	100	2
SITUATION II: Boarding	100	13,7
SITUATION II: Airport Facilities	100	4,9
SITUATION II: Wheelchairboarding	100	3,3
SITUATION II: UM Boarding	100	0
SITUATION II: Special Loading (e.g. musical instrument)	100	1
SITUATION II: VIP Boarding	100	5,9
SITUATION II: Missing Flight Documents	100	2
SITUATION III: ATC Request	95,1	99
SITUATION IV: Aircraft Change	95,1	63,1
SITUATION IV: Crew Duty Change (new duty roster)	95,1	18,4
SITUATION IV: Crew Change (new crew member)	95,1	1,9
SITUATION IV: Technical Repair	95,1	7,8
SITUATION IV: Other	95,1	3,9
SITUATION V: Crew Proposal: Connecting Passenger	93,2	5,8
SITUATION V: Crew Proposal: Necessary A/C repair	93,2	33
SITUATION V: Crew Proposal: Avoidance of A/C Change	93,2	47,5
SITUATION V: Crew Other Proposal	93,2	5,8

Effect of Process Delay on Departure Punctuality

A significant correlation could be identified for turn-round processes which produced a delay in relation to the departure delay after turn-round as shown in percent of all reported delays. However, since values of both variables result from qualitative assessment of the situations, only subjective information can be deducted. The following figures show the proposed situations; late parking stand assignments (figure 5), ramp & terminal service delivery (figure

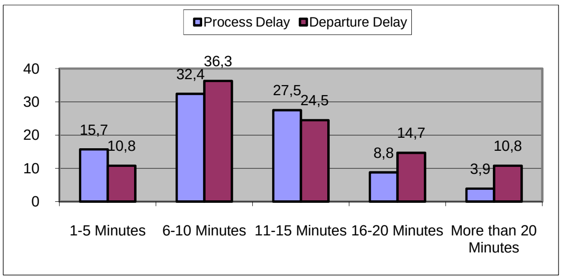
6), operational information sharing *to* cockpit (figure 7), and operational information sharing *from* cockpit (figure 8).

Figure 5 - Process & departure delay for parking stand assignment



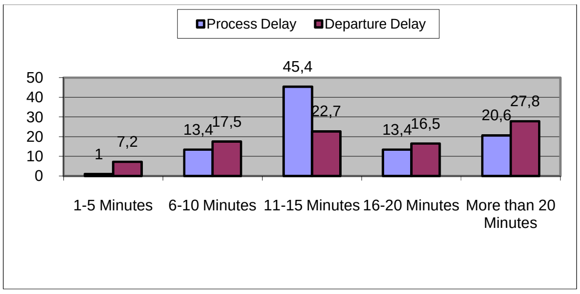
Note: Spearman's rho = 0.363, p=0.001, two tailed test, N=84

Figure 6 - Ramp & terminal service delivery



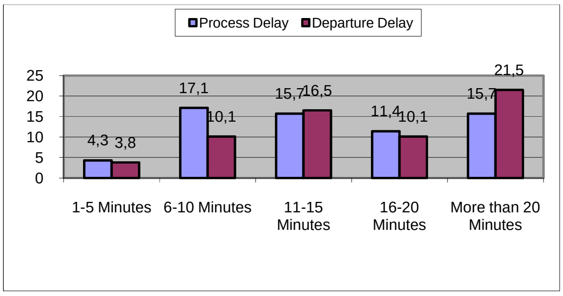
Note: Spearman's rho = 0.424, p=0.000, two tailed test, N=102

Figure 7 -Operational information to cockpit



Note: Spearman's rho = 0.760, p=0.000, two tailed test, N=97

Figure 8 - Operational information from cockpit



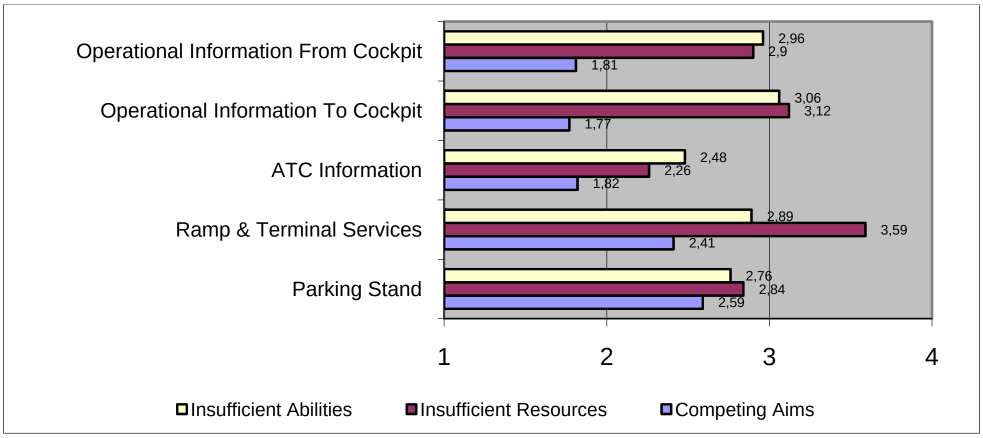
Note: Spearman's rho = 0.854, p=0.000, two tailed test, N=79

Even though it is not possible to infer that the turn-round process delay exclusively causes the overall departure delay, it entails a high risk of being responsible for the delay since also the *amount* of delay correlates significantly between process delay and departure delay. It can be argued that this result is based on a subjective assessment by pilots and is therefore not based on real turn-round data. However, in all situations pilots are always directly affected by the delay and physically present when the turn-round takes place.

Possible Cooperation Failure during Flight Operation

Even though it could be argued that pilots would be unable to identify failure causes objectively, it is very likely for following reason: pilots have operational experience from a home base airport which they are familiar with. Since all participating pilots fly for airlines having a large network, pilots can easy compare turn-round services from other airports with their home base. This allows a unique way to compare service provision of various airports. Figure 9 compares the mean ratings for aims, resources, and abilities as causes of possible information sharing failure by pilots.

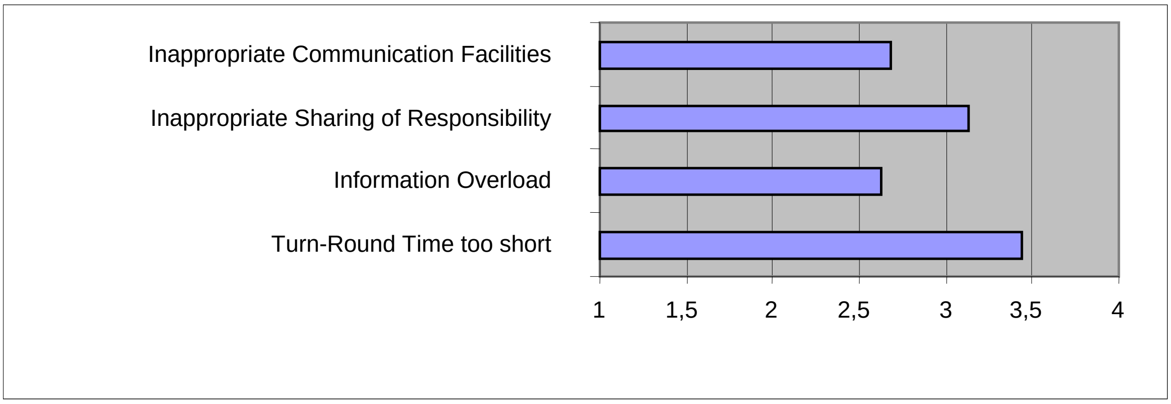
Figure 9 - Possible information sharing failure causes



During all situations except ATC information, insufficient resources were seen as being primarily responsible for turn-round delays. Ramp and terminal services in particular, appear to be particularly affected by the problem of insufficient resources. The only non-cooperative situation from pilots' perspective, analogous to Ferber's cooperation model, is the pilots mean rating for the assignment of parking stands.

Pilots were also asked to report about possible other reasons for process failures. Most frequently reported causes included the following in Figure 10. The first reason refers to a turn-round time which is too short: If this is the case, there is not sufficient time to compensate for any process delay. The second reason implies that important information may be hidden among the unimportant. The third reason is that there appears to be an inappropriate sharing of responsibility functions for decision making, and last reason refers to inappropriate communication facilities in order to address concerns during turn-rounds.

Figure 10 - Possible other reasons for problems with the turn-round process



6. DISCUSSION & REVIEW PROCEDURE

The most important result from the survey is captured by the apparent consensus that exists between pilots that information sharing is a root cause for process failures during flight operation. Furthermore, what was particularly noticeable from the survey was the frequency of these reported events. The survey also found that a strong relationship exists between on the one hand the delay from a service or information provision failure and on the other hand it's effect on the departure punctuality of the following flight for all contemplated situations. Additionally, in almost all reported events, departure delay was more significant after turn-round as a result of information provision failure compared to delay caused by service provision failure. A possible explanation could be the so-called phenomenon of a bullwhip-effect where the network of service providers can oscillate in very large swings as each organization in the supply-chain (critical path of turn-round events) seeks to solve the problem from its own perspective and so raising the outcome of the problem (here the outcome is the departure delay after passing the critical path of ground handling services). This is a very common problem in the management of production lines where many partners are involved. However this has to be validated via additional information collection because the delay following a service/ information provision failure could also be caused by other not yet identified factors.

No correlation could be observed between proposed information provision to cockpit and a consequent avoidance of ground handling service delay. This is because either pilots are not aware of the opportunity to avoid a potential problems through usage of the supplied information (e.g. arranging alternative ways of ground handling), or there exists a real lack of resources, capabilities, aims, or other not yet identified reasons responsible for service delays.

Surprising high results were reported from delays caused by failures to provide operational information from and to the cockpit. This finding provides some indication as to the cockpit's perspective on the problem and how *airlines* or *ground handlers* are managing the operational processes. Contemplated operational problems included e.g. changes of equipment, parking position, or crew, re-booking or direct transfer of connecting passengers. Operational planning for such events requires pre-planning with other airport partners and is necessary in order not to maintain the integrity of pre-planned departure times.

Overall, this study is the first attempt to understand the cooperation building process during Airport Collaborative Decision Making. It could be identified that the distributed CDM environment showed unique interaction characteristics with multiple individual operators' goals settings, while the airline pilot's perspective revealed being useful for the analysis of possible operator's thoughts.

De Ferber's interaction model identified potential non-cooperative behaviour during flight operation. The results from the questionnaire should now be used to evaluate a re-design of the currently used CDM approach. New design elements should recognize the problems of human information interactions during flight operation, as well as operators' behavioural characteristics assessing the complexity of each individual flight operation situation.

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Biometric Access to Training Devices as a Security Protocol in Flight Training

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ABSTRACT

Mechanical locks and keys are conventional access control devices utilized for both flight training devices and training aircraft, but keys can be copied, locks can be bypassed, and in the case of electronic flight training devices, unqualified instructors or students may utilize the equipment, possibly causing the equipment to fail. The faculty in the Aviation Technology Department at Purdue University performed this study to determine if biometric usage is a feasible and secure method in operating a flight training device and eventually securing an actual aircraft versus the older lock and key method. A Finger-vein biometric reader was installed onto a Frasca Advanced Aviation Training Device (AATD) and the software was installed such that identification had to be made prior to the program being able to initialize. The data collected from the survey includes information such as user interface issues and conditions which affect the failure reads such the placement of the flight instructor's finger on the biometric device.

KEYWORDS: Aviation Security, Security Threats, Biometrics, Biometrics Access Control, Finger-vein Reader, Flight Training Devices, Flight Simulation Devices

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1. INTRODUCTION

There needs to be a balance between necessary security protocols and flight instructor and student access to various training devices that are utilized in flight training. Up to this point, the usage of mechanical locks and keys has been a primary boundary to access both flight training devices and training aircraft. Even with a key sign-out protocol or dispatch office in place there are still areas where security can be breached and unwanted access can be obtained. Keys can be copied, locks can be bypassed, and in the case of electronic flight training devices (i.e. Frasca Advanced Aviation Training Devices, AATD), unqualified instructors or students may utilize the equipment for fun or in order to determine how it works, thereby causing unnecessary wear and tear.

2. LITERATURE REVIEW

2.1 AVIATION SECURITY

Security in the aviation industry has been based on three basic premises; positive identification and screening of passengers, screening of baggage, and verification that both passengers and baggage each board the aircraft. There have also been a variety of processes established to determine whether or not a particular individual poses a threat to an aircraft on a particular flight with varying degrees of success. In addition to passenger screening and identification, screening of baggage has evolved to the point where everyone and everything is screened at various levels prior to boarding an aircraft. Finally, only individuals that have a boarding pass and government issued ID are allowed beyond a security checkpoint which reduces the possibility of a "safe" individual checking-in and then handing the boarding pass to someone with a harmful intent. While these security protocols work for the commercial airline industry and are supported by government agencies and funding, they do not exist for corporate aircraft, the charter industry, general aviation airports or even flight training facilities. Individuals with the financial means to acquire a corporate aircraft do so to save travel time and forgo the security processes. Furthermore, typical passengers on corporate aircraft are well known to everyone involved from the scheduling deputy to the line crew to the pilots and the successful outcome of the flight is seldom in doubt. In many instances there is no need to determine whether or not an individual poses a threat to the aircraft since it would be obvious if a "non-approved" individual tried to gain access. The intent of this literature review is to illustrate many of the specific security protocols used for commercial aviation, to highlight the potential government mandates that are being considered for business size aircraft and to create a testing platform to identify processes which can be adopted or modified for commercial and corporate aircraft, the charter industry and even for the general aviation airports and training locations.

2.2 POTENTIAL SECURITY THREATS

Various agencies have identified multiple types of security threats from different entities and individuals. As reported by Paul Proctor (1987) in “Corporate Concerns About Terrorism Spurs Sales of Security Systems”, the National Business Aircraft Association suggests operators with aircraft security systems should use them at every destination, no matter how brief the stay, because "it doesn't take very long for a bomb to be placed or a hydraulic line to be cut." While this type of security threat is to be considered, there are low cost alternatives typically available such as security fencing, restricted access to ramps, and watchful personnel on the airport ramp. Acquisition of an aircraft and the potential usage of it for harmful purposes is another matter. Although the extent of potential damage from light, corporate, and training aircraft is debatable, there is a real possibility that these aircraft are being targeted for terrorist activity. Eric Lichtblau (2005), in his report on US aviation security holes, refers to a government report which detailed particular vulnerabilities in what it called "the largely unregulated" area of general aviation, which includes corporate jets, private planes and other unscheduled aircraft. Mr. Lichtblau (2005) also references a previously undisclosed 24-page special assessment on aviation security by the Federal Bureau of Investigation and the Department of Homeland Security which indicates that Al Qaeda may have discussed plans to hijack chartered planes, helicopters and other general aviation aircraft for attacks because they are less well-guarded than commercial airliners.

2.3 PASSENGER AND BAGGAGE SECURITY SCREENING SYSTEMS

The US government has started many nationwide programs to determine whether or not an individual poses a threat to an aircraft. The most current program being highlighted for commercial aviation is the registered traveler program. Mark Prismon and David Johnston

(2004) quantify the main initiative underlying the program as to allow frequent fliers to volunteer for a criminal background check in exchange for a shorter security process at the airport. Mr. Prismon and Mr. Johnston (2004) also say that the program will require a fingerprint and iris scan to be taken at security stations to confirm identities. As of today there are only a select number of airports that are utilizing this program with various levels of success. There have been other systems before the registered traveler program. The Computer Assisted Passenger Prescreening Program (CAPPS) was one of the first screening programs initiated and implemented. The idea behind the CAPPS program was that by checking each passenger's address, name, phone number and date of birth, the airline could verify that the passenger was who they claimed (Wall Street Journal). In 2003 the newly formed Transportation Security Agency (TSA), which had previously been part of the Department of Transportation, set out to create a new version of CAPPS, popularly termed 'CAPPS II', and as initially proposed, CAPPS II was to be the transportation security equivalent of the credit report or mortgage score (Curry, 2004). Data about the individuals from their Passenger Name Records (PNR) would be linked with data available both publicly and in government files computing a score, and using the most sophisticated of statistical tools, passengers would be categorized as green, orange, or red, as trustworthy, perhaps questionable, untrustworthy, or even treacherous (Curry, 2004). This assessment of risk would then be utilized to allow access to an aircraft or increase the level of security necessary before a passenger is allowed to board. This of course assumes that the airline or commercial operator has a protocol established to handle individuals that are a perceived risk. In actuality one of the largest problems facing the CAPPS II program regards the action the airlines would undergo when finding a suspicious traveler (Prismon & Johnston, 2004). According to Mr. Prismon and Mr. Johnston (2004), in many cases, the airlines did not report the match to the government and in other cases the airlines did not properly remove the person from flying. This lack of reporting and response is contrary to the designed intent of the CAPPS II program.

In response to long waiting lines for airport security screening, the "Trusted Traveler" and "Registered Traveler" programs were introduced. According to the US General Accounting Office (GAO), many stakeholders believe that the Registered Traveler program will enable the Transportation Security Administration (TSA) to more efficiently use its limited resources by "more cost-effectively focusing its equipment and personnel needs to better meet its security goals" (US General Accounting Office, 2002). The Registered Traveler program contains Personal information that can include any of the following: full name, current home address, current home phone number, current cell phone number, social security number, date of birth, place of birth, nationality, gender, prior home addresses, arrival date in US, digital photo, biometric reference, unique identification record number, Registered Traveler eligibility status, and information provided by Federal, State, and local government agencies and foreign governments that is necessary to carry out a security evaluation (Walters, 2004). The Registered Traveler program has been presented and promoted as a time savings option for airport security that shifts a portion of the operations cost to those individuals that choose to utilize the program. There is a registration and yearly operation fee that becomes worthwhile if an individual does extensive amounts of travel. On the other hand, for those individuals that travel sporadically or during relatively low travel periods the Registered Traveler program has not shown to save security screening time. There are individuals and groups that are less than excited and somewhat skeptical about the Registered Traveler program. Privacy advocates have raised concerns about possible data that may be included on the card in the future, and see the potential that when registering for the program the government can potentially check one's past criminal records (Prismon & Johnston, 2004).

Also, the need for tracking baggage and matching it to passengers has created a trend to shift from workload intensive barcode scanning technology to Radio Frequency Identification (RFID) on luggage. RFID technologies can assist in identifying exactly which baggage is in which container, match the baggage to the passengers and even provide an 'aboard aircraft' status, as well as exactly locate the container which holds the passenger baggage, all of which is invaluable from both security and operational efficiency standpoints (Cerino & Walsh, 2000). An RFID tracking system will allow baggage sorters to quickly identify a bag if it must be removed from an aircraft in the event a passenger fails to board an airplane or did not even pass the security checkpoint.

2.4 CORPORATE AIRCRAFT SECURITY

While commercial aircraft security is focused around the identification of passengers, an assessment of the perceived risk of those passengers, and positive matching of passenger manifests to loaded baggage, corporate aviation security can be maintained by simply assessing the perceived risk of the passengers. While the amount of collateral damage caused by destroying a commercial aircraft in flight is significant, the potential impact of destroying a corporate aircraft in flight is significantly diminished. Destroying a corporate aircraft in flight is counterproductive for terrorist activity and there are much more attractive ways of utilizing a corporate aircraft to cause damage.

Security for corporate aircraft has centered on increased vigilance for the reduction of possible security breaches and increased regulation by government agencies. The National Business Aircraft Association (NBAA) has expressed concerns about potential regulations from various government agencies. On the NBAA website they state, “The Department of Homeland Security (DHS) and the Transportation Security Administration (TSA) are reviewing new security protocols for general aviation (GA) - What can the industry do to reduce its exposure to threats and maximize the flexibility required for operational missions?” The current concern centers around additional regulations for international flights that were proposed by the FAA on September 18, 2007 in a Notice of Proposed Rule Making (NPRM) document. Currently any aircraft that enters US airspace on an international flight must make prior notification of the time, place of entry, and the number of individuals on board the aircraft. The proposed rule would require flight crewmembers to compare the passenger manifest information with the information on the Department of Homeland Security approved travel document presented by each individual attempting to travel onboard the aircraft to ensure that the manifest information is correct, that the travel document appears to be valid for travel to the United States, and the traveler is the person to whom the travel document was issued. Without access to the appropriate equipment and databases, this places an undue burden on the flight crew. Furthermore, unlike commercial aviation where the security stations are in a fixed location, corporate security locations must be as mobile as the aircraft themselves so that the flexibility of operating a corporate or charter aircraft is not sacrificed.

2.5 FLIGHT TRAINING FACILITIES SECURITY

Many universities and local airports have flight simulators and training devices housed at their flight training facilities. Flight trainers and simulators are utilized for educating future and even current pilots on flight maneuvers, methods, and processes. These items are of high value and contain important information regarding airports and flight paths and they, too, need to be secured at all times. Many of instructors at these flight facilities train future and current pilots on security awareness, but securing these facilities requires more than security awareness training of the employees and students. Many of the training facilities are open to the public during the week and have little or no access control limitations. If the public can access the facilities, then, there is a high possibility that they can also access the flight simulators, too, even though they are unauthorized to do so. It has even been said that the 9-11 hijackers, who flew and crashed the commercial airplanes into the World Trade Center, even trained at local flight schools. Not only would access control devices have prevented these individuals from entering these premises in an unauthorized fashion, but if these flight school employees had access to a security-type database, they may have been able to check their backgrounds and delayed the education process for them.

2.6 SHORT TERM SECURITY SOLUTIONS

An appropriate response to security threats is not always cut and dry. There are many factors and variables that need to be considered. Like any problem, the most simple and tangible actions are taken first while specific programs are evaluated for later deployment. Security Directive 96-05, issued in August 1996, declared that, "all passengers who appear to be 18 years of age will present a government issued picture ID, or two other forms of ID, at least one of which must be issued by a government authority" (Curry, 2004). While the requirement to present a government issued photo ID is a positive and necessary step, the overall increase in security relies heavily on the ability of individuals to make quick assessments as to whether or not the individual presenting the government issued picture ID is in fact the person they claim. Combine that with the fact that many Government IDs can be counterfeited and this is only a stepping stone to a complete system. Mr. Curry illustrates the directive, and like systems before, as tending to rely on the coherence of a person's identity - Is this person the one whom he claims to be? If the airline employee believes so, then the terms of the regulation have been met (Curry, 2004).

If there is a perceived threat then an obvious step to strengthen security is to increase the number of trained security professionals overseeing operations with increased risk. In response to potential threats, federal officials now say they have taken a number of steps to tighten security for helicopters, chartered flights and the like, as they did previously in temporarily ordering federal security guards and tougher screening for helicopter tours in the New York City area (Lichtblau, 2005). Quick and effective responses to specific threats are vital to the overall security net around the world. However, each security protocol that is established takes significant manpower to staff, burdens the flight operation, and eventually must be shifted to higher risk, higher priority areas to respond to more recent threats. The US government wants the same level of security on corporate and charter aircraft that they desire on commercial aircraft while individuals that utilize corporate and charter companies want the same freedoms they have come to enjoy with the significant costs that they support. These two ideals can be achieved with the proper planning and security devices and thorough evaluation. There must be a system established that will allow minimally trained individuals with a significant degree of investment and culpability to access data, assess the perceived risk, and make informed decisions as to whether or not to continue an operation or secure additional input.

2.7 BIOMETRICS AND BIOMETRIC DEVICES

Biometrics is the automated use of physiological or behavioral characteristics to determine or verify identity (2008). Biometric modalities can include traits such as the hands (hand geometry), fingerprints, iris, veins, voice and even keystroke dynamics from a computer keyboard. These biometric traits are used as a means for authentication by various biometric device readers. A human characteristic can be used for biometrics in terms of the following parameters:

- **Universality** each person should have the characteristic
- **Uniqueness** is how well the biometric separates individually from another.
- **Permanence** measures how well a biometric resists aging.
- **Collectability** is the ease of acquisition for measurement.
- **Performance** accuracy, speed, and robustness of technology used.
- **Acceptability** degree of approval of a technology (Jain, 2004)

There are a variety of biometric modalities, none of which are a solution to all threats or risks. Given that the majority of biometric devices were available at Purdue University, from the Biometric Standards, Performance and Assurance Lab, an evaluation of modalities was undertaken. Some of the modalities were limited, due to the need to interact with the operating system but not impact the operation of the Frasca. Therefore single sign on software was needed, and this limited the biometric modality choice to fingerprint, finger-vein, and face. The team decided on finger-vein, as it was a relatively new biometric modality and suited the needs outlined by the group. Being that the hand vein ranked Medium (M) for all six parameters, the researchers at Purdue preferred such a biometric, but only had access to a finger-vein reader, which works similar to the hand vein reader. A commercially available finger-vein device was chosen for this study. One of the advantages for selecting this device was that it was compact in size and could easily be placed near the flight simulator computer. To operate, near-infrared light is transmitted through the finger and partially absorbed by hemoglobin in the veins. The device then captures and extracts this information to match against a previously stored template. All of the individuals were enrolled into the system, and subsequently identified each time they needed to access the flight simulator computer.

3. METHODOLOGY

The Federal Aviation Administration (FAA) would require extensive testing and approval before allowing a biometric device to be installed in an actual aircraft, so the Frasca Advanced Aviation Training Device (AATD) at Purdue University was utilized for this research project. Because of the extensive time and paperwork necessary to install a biometric reader in an actual aircraft, the AATD is an easier and more controlled platform from which data can be obtained and modifications can be made during the test period. The Aviation Technology Department at Purdue University acquired this new Flight Training Mentor Device, which has the latest technology of avionics for general aviation aircraft, in the Spring of 2007. The avionics package consists of the Garmin G1000, which is an all-glass avionics model. The Hitachi H1 Logical Access finger-vein reader was installed onto the Frasca Advanced Aviation Training Device (AATD) in the Fall of 2008. The biometric reader software was installed such that identification had to be made prior to the Frasca AATD software program was able to initialize. This allowed only designated Purdue flight instructors to turn on and off the flight training device, increasing its security.

Before the flight instructors were able to utilize the biometric, they first had to be enrolled into the biometric software. To do so, the researchers asked each flight instructor to place their finger of choice onto the finger-vein reader. A template of the finger-vein pattern is stored, and subsequently used for identification at a later date. The enrollment process only takes a few seconds per individual, resulting in 60 flight instructors to be enrolled. - The research team then briefly discussed the reader's operation with the flight instructors as a group. The biometric software program was also setup so that the flight instructor would first input a standard instructor password (same for all instructors) and then have the finger-vein scanned for the computer system login. If both the password and finger-vein scanning matched the biometrics database, then the software program for the flight simulator would start and the devices on the simulator would also light up.

4. RESULTS AND DISCUSSION

The objective of this research project was to test a commercially available finger-vein reader, integrated with the computer login of a Frasca flight trainer, to test its effectiveness as an access control device as well as determine its feasibility of use. Installing the biometric reader on the flight trainer did indeed prevent unauthorized individuals from powering the trainer on. If the incorrect password was inputted, the flight instructors were unable to power up or operate the flight trainer. Also, if the incorrect finger (but the correct password) was placed on the biometric reader, the person would not be able to access the simulator. If the flight instructors did not place their finger properly on the reader, they, too, were unable to access the trainer. In addition, 20 additional students, not enrolled in the biometric software, were asked to place their finger on the biometric reader, and each time, the biometric software displayed a failure note and the simulator never powered on. The researchers were also able to view the biometrics login log to see all the failed attempts to access the system. General performance characteristics, such as a Receiver Operating Characteristic curve was not calculated at this time. There were no failures to enroll on this device.

The previous method of preventing unauthorized access to the training devices was only limiting access to the simulators after 5pm, when the department officially closed. Once the normal hours of operations cease, the exterior doors of the simulator building are locked and the only access into the building is with a key or a code. The flaw in the punch-code entry door is that the code has remained the same since the door was installed four years ago and the number is common knowledge among many faculty, students, staff and airport employees. During the normal work hours of 8am to 5pm, the students, faculty, flight instructors and anyone at the airport can access the flight trainers because there are no preventative measures to overcome in order to gain access to the training devices. The simulator building doors are unlocked and the interior door to the simulator room is also unlocked. Once access has been gained through the doors of the building, the Flight Training Devices can be turned on by anyone who chooses to turn on power to the computers.

In order to understand the user's acceptance of the finger-vein reader, the flight instructors were asked to voluntarily participate in an online survey. This allowed the researchers to gather data from the participants and at the same time allow the participants to remain anonymous in their answers. Of the 60 flight instructors, 43 replied to the online survey, giving a 72% return rate. These flight instructors also ranged in age from 19 – 25 years old, with an approximate mean of 21.5 years. The actual survey can be seen in Appendix A. In the survey, the flight instructors were asked to rate the overall ease in using the finger-vein reader, using five ratings. Of the 43 respondents, 19 selected 'Very Easy', 17 selected 'Somewhat Easy', 5 selected 'Somewhat Difficult' and 2 selected 'No Response'. In addition, the 5th rating 'Very Difficult' was not selected by anyone. From these selections, one can determine that over three-fourths (84%) of the respondents selected one of the 'Easy' choices. This indicates that there was a positive response to the addition of the finger-vein reader and it did not negatively impact the usage of the flight training device.

In the survey, the flight instructors were also asked to choose from 4 choices, based on their usage, if there was a learning curve associated with the biometric device. Of the 43 respondents, 19 selected 'No Learning Curve', 21 selected 'Slight Learning Curve', 1 selected 'Large Learning Curve' and 2 selected 'No Response'. From these selections, one can determine that most (93%), of the respondents selected one of the 'No or Slight Learning Curve' choices.

This highly positive response rate indicates that the addition of a finger-vein reader is mostly intuitive as to its use and most users were habituated in a very short time. Deployment and training costs are something that needs to be considered when deploying a biometric system. These results are very positive with respect to user habituation.

The flight instructors were also asked to choose from 4 choices, based on their usage, which access control method they preferred for the simulator application. Of the 43 respondents, 1 selected 'Lock and Key', 13 selected 'Username and Password', 27 selected 'Biometric', and 2 selected 'No Response'. From these selections, one can determine that over half (63%), of the respondents selected 'Biometrics' as a preferred method for simulator access control. Another 30% selected 'Username and Password', of which the password was also utilized along with the biometric scanning. It may have been worthwhile for the researchers to also provide the choice of 'Biometric and Password' to determine if those who chose the 'Username and Password option also preferred the biometric device. From these 3 sets of answers, the researchers then concluded that installing a biometric was indeed feasible for the simulator since many of the survey respondents felt the biometric was easy to use, did not require a large learning curve to use, and also preferred biometrics as the choice for access control for the simulator.

5. CONCLUSION

There are many facets to aviation security. As illustrated in the literature review there have been extensive efforts to identify the potential threat of passengers. Extensive measures are taken for each commercial flight to ensure that only those individuals for whom the sole purpose is for traveling from one location to another board the aircraft. Pilots and crewmembers are screened at the security checkpoints as well, but there have not been sufficient measures taken to prevent an unauthorized individual from gaining access to an aircraft while it is sitting on the ramp. Just like the cockpit of an aircraft, flight simulators also need to be limited to authorized and qualified individuals only. This research study determined that installing a biometric reader onto a flight simulator was indeed effective as an access control device and also feasible to use. Through the use of the survey and in the opinion of the respondents the addition of the biometric reader did not reduce the usability of the device. It added a level of security that had not been present in the past and allowed the individuals responsible for the care of the flight training device to access the usage log to determine date and time of use in addition to which flight instructor accessed the machine. This not only added security but increased accountability for those utilizing the machine in case something needed to be repaired. Overall the addition of the biometric reader was a significant success and it offered tremendous insight into the potential problems associated with installing such a device on an actual aircraft. The researchers plan to next test other biometric devices on actual commercial and cargo size aircraft as well as continue testing biometrics devices on the remaining simulators in the building. The goal of the researchers is to have a biometric on every simulator and training aircraft utilized by the Aviation Technology Department at Purdue University. Another change the researchers would like to try for future studies would be to survey a wide spectrum of pilots, since the mean flight instructor age of this study was 21.5 years of age. While this is the mean age of instructors in the flight program at Purdue University, this is not the mean age of flight instructors or pilots currently in the aviation industry.

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APPENDIX A: ONLINE FLIGHT INSTRUCTOR SURVEY

Flight Sim Finger-vein Survey

* Required Question(s)

Demographic

***1. What best describes you?**

- Student
- Trainer
- Faculty or Staff

***2. How long have you used the G1000 flight simulator?**

- 0 - 3 months
- 3 - 6 months
- 6 - 10 months
- 10+ months

***3. What is your age?**

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***4. What is your gender?**

- Male
- Female

***5. Which is your dominant hand?**

- Left
- Right
- Ambidextrous

***6. What types of biometric scanners have you used?**

- Fingerprint
- Retina
- Iris
- Voice
- Face
- Hand Geometry
- Signature

***7. Which hand did you use to register?**

- Right hand
- Left hand

***8. Which finger did you use to register?**

- Pinky finger
- Ring finger
- Middle finger
- Index finger

***9. Do you know what physical characteristic is measured?**

- Yes
- No

***10. How would you rate the overall ease in using the finger-vein scanner?**

- Very easy
- Somewhat easy
- Somewhat difficult
- Very difficult

***11. Was there a learning curve associated with using this device?**

- No learning curve
- Slight learning curve
- Large learning curve

***12. What was your overall impression in using this biometric scanner?**

- Liked it a lot
- Like it somewhat
- Disliked it somewhat
- Disliked it a lot

***13. Do you have any anxiety toward using a finger-vein scanner?**

- I have no anxiety
- I have a little anxiety
- I have moderate anxiety
- I have a lot of anxiety

***14. Based on your experience, which access control method would you prefer for this application?**

- Lock and key
- User name and password
- Biometric

***15. Would you use this technology to log onto your PC at home or at work?**

- Yes
- No

***16. What suggestions do you have for making this process better? (Different Biometric, Scanner position...)**

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