MASSEY UNIVERSITY
SCHOOL OF AVIATION

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3rd Aviation Education and Research Symposium

"Contemporary Issues in Aviation Education and Research"

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Foreword

Massey University School of Aviation is pleased to announce the third Aviation Education and Research Symposium to be held at Wellington on 05-06 July 2010, in conjunction with the Aviation Industry Association of New Zealand and Royal Aeronautical Society, New Zealand.

Encouraged by the success of the previous two seminars, we have continued with sessions that enable both academics and practitioners from the aviation industry to share views and developments. The event will be a venue for disseminating research, and an opportunity for theory and practice to converge.

We have retained the same theme "*Contemporary Issues in Aviation Education and Research*", as this appears to attract a greater spectrum of submissions across aviation psychology, education, technology, training, and the economic aspects of the industry. The conference papers have been peer-reviewed and classified into three sessions, with '*Aviation Training*' on the first day, followed by '*Aviation Psychology*', '*Aviation Education*' and '*Commercial Aspects of Aviation*' on the following day.

We welcome delegates to attend, participate and share information on the latest developments in the industry.

Ashok Poduval
CEO - Aviation

AVIATION   TRAINING

PC-based aviation training devices (PCATDs): research, development and certification

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Abstract. *This paper examines the development of two PCATD's (one helicopter, one fixed-wing) and their eventual certification by CAA. Certification has demonstrated the potential these devices have for aviation training in New Zealand. Traditionally FTD's and PCATD's have been sourced from foreign companies, and they represent a considerable financial investment for large flying training organisations. The procurement of these simulator types is generally beyond the financial resources of most small to medium sized flying schools. Aviation training in NZ is facing significant financial constraints as well as an increasing demand to simulate complex glass cockpit systems that are now installed in most new General Aviation (GA) aircraft. The development, utilisation and certification of this type of PCATD technology could solve these difficult challenges.*

Introduction

The multitude of resources required to implement flight training impose a significant burden on the many organisations that form the aviation community. The increasing demand for flight simulators is one area of aviation training that has shown unprecedented growth. Rapid advances in computer technology have continued to accelerate the development of sophisticated flight simulators. By utilising these simulators, aviation organisations have been able to conduct more realistic ground training and reduce training time in the aircraft (Rolfe, 1989). Also the introduction of a new Multi-crew pilot Licence (MPL) for airline co-pilots requires a greater use of simulators as opposed to the traditional commercial pilot's licence (CPL) pathway.

However, the acquisition of a certified Flight Training Device (FTD) is still beyond the financial resources of most flight training schools and small commercial operators in NZ. An alternative strategy that is gaining momentum is the utilisation of low cost PC based training devices (PCATD's) for flight instruction and currency training[1]. A number of research studies have indicated that although the fidelity[2] of PCATD's in comparison to FTD's is low, especially in control loading and flight dynamics, there is increasing evidence of positive transfer of training from the PCATD to the aircraft (Dennis & Harris, 2008).

In the last four years the School of Aviation (SOA) at Massey University has implemented two research projects involving the development and evaluation of low cost PCATD's, designed specifically for aviation research and flight training.

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[1] Pilots are required to maintain instrument flying competency by completing a set number of instrument approaches in the aircraft and flight simulator every 6 months.

[2] Fidelity is a measure of the equipment and environmental cues of the flight simulator and how they relate to the real aircraft.

Auckland Rescue Helicopter Trust PCATD

The first collaborative project involved the development of a PCATD for the Auckland Rescue Helicopter Trust (ARHT). The PCATD was closely modelled on the MBB/Kawasaki BK.117 helicopter used by ARHT and was developed to assist the trust with currency (IFR/VFR) training for their operational pilots (Reweti, Gilbey & Jeffrey, 2010).

At the time, a survey of commercially available FTD's found that the cost of these simulators ranged from $400,000 to $1 million NZ dollars, well beyond the financial resources of the trust. In fact the PCATD specifications posed significant challenges for the development team as the ARHT's initial budget for the project was only $70,000. Also the PCATD had to simulate a reasonable level of flight control reliability and visual fidelity as well as accurately simulate the complex avionics and navigation systems currently operating in the real helicopter.

Apart from currency training, a secondary aim of the project was to develop the PCATD to a level of fidelity and conformity that would achieve Civil Aviation Authority (FSD2 Synthetic Flight Trainer) certification. Access to a certified PCATD meant ARHT pilots could log up to 20 hours of instrument simulator time towards an instrument rating and also maintain instrument approach currency.

The ARHT Chief Pilot Dave Walley has stated that, "Because we fly a lot on instruments, our pilots have to practice constantly to keep their skills up. Without this simulator we would have to spend large amounts of money utilising our helicopters for skills training. The support from Massey University and Savern Reweti has been a very important factor in successfully completing this project." The PCATD was finally completed in early 2010 and achieved CAA certification in September 2010 (see Appendix 4).

Diamond DA 40 PCATD

The second research project was more close to home, and coincided with the School of Aviation purchasing a new fleet of Diamond DA 40 training aircraft. One distinctive feature of the Diamond DA 40 is that it is equipped with a Garmin 1000 glass cockpit suite (see Fig.1).

Figure 1: School Of Aviation Diamond DA 40 Panel (Real)

The Garmin 1000 is a significant upgrade to the more conventional flight instruments and avionics found in most general aviation aircraft. The glass flight deck presents flight instrumentation, navigation, weather, terrain, traffic and engine data on large-format high-resolution displays (see Fig. 2). This sophisticated cockpit can provide trainee pilots with a high level of situational awareness, flight monitoring capability, and system management skills. An important advantage of this type of training is that after graduation a glass trained pilot can make an easier transition to a corporate jet or even the Boeing or Airbus cockpit of a national carrier.

Figure 2: Simkits & Flight 1 Glass Cockpit Primary Function Display (PFD)

Once again the challenge was to develop a low cost PCATD modeled on the Diamond DA 40 that could be used for aviation research purposes and to enhance the new SOA Diamond DA 40 scenario based training program. A significant challenge in developing this PCATD was the requirement to emulate the Garmin 1000 and its myriad of integrated systems. These included an Attitude and Heading Reference System (AHRS), GFC 700 Autopilot, Terrain Awareness and Warning System (TAWS), and Traffic Information Services (TIS). To assist in achieving a wide range of research outputs the PCATD design would also include a motion platform; multi-screen visual displays, a fully functional cockpit, and a networked instructor station (Fig. 3).

A commercially available FTD with all of these capabilities would have cost between about $300,000 to $1 million NZ dollars. By using innovative design techniques and adopting a DIY philosophy, a research budget proposal of $82,000 was applied for, and approved in 2009 (Pérezgonzález, Reweti & Lee, 2009). The PCATD project was completed in November 2010, and CAA certification was achieved in May 2011 (see Appendix 5).

Figure 3: Diamond DA 40 Motion Based PCATD
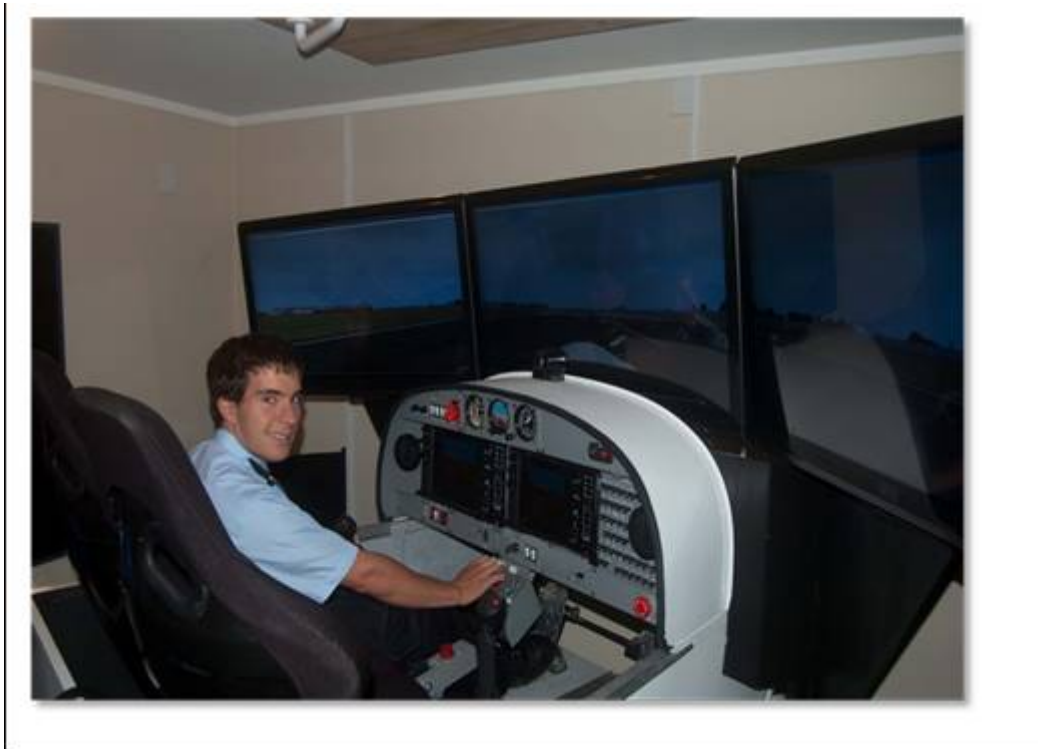
One of the important principles in the design of the PCATD was to utilise 'commercial off the shelf' (COTS) hardware and software wherever possible, and minimise the use of proprietary equipment. Another strategy to reduce development costs was to use a variety of inexpensive open source software programs and modify them to achieve the project requirements.

PCATD software engine

The primary software engine that is used to drive the PCATD prototype is Microsoft Flight Simulator FSX Gold (FSX) which also contains several Software Development Kits (SDK's). SDK's are critical as they enable the development of customised software modules that can directly interact with the MSFS SimEngine. The intention is to upgrade the software platform in the near future to Microsoft ESP which is the commercial version of FSX. This is a necessary requirement to protect the intellectual property of the PCATD if it ever reaches a commercial production stage.

The 28 year old Microsoft Flight Simulator franchise is now generally considered to be less of a recreational software game and more a software platform that can generate a complex virtual aviation environment. FSX contains an improved 3D global setting that allows you to fly over the polar icecaps, displays true road data and renders region specific textures. Also the maximum altitude was increased from 60,000 ft to 100,000 ft. The visual database contains over 20,000 airports and an accurate rendition of global scenery with a resolution of 7cm/pixel (Microsoft, 2010). A number of NZ software developers including SOA staff and students have produced high quality add-on locally based NZ terrain and airport scenery.

These scenery modules are detailed enough to be used for Visual Flight Rules (VFR) training. One NZ company, Vector Land Class, has utilised sophisticated mapping

techniques to produce high resolution NZ terrain (see Fig. 4). This detailed scenery is accurate enough for cross country navigation and Instrument Flight Rules (IFR) training (Barnes, 2010).

Fig 4: Vector Land Class NZ Terrain

Garmin 1000 simulation

The ability to simulate the real-world Garmin 1000 Glass Cockpit in a cost effective way was a major challenge. Two recent technological developments of COTS hardware and software were effectively utilised in the development of the Diamond DA 40 PCATD.

Simkits replica Garmin TRC1000

The Simkits replica Garmin TRC1000 is a 100% scale replica of a real Garmin G1000 Glass Cockpit System as found in the Diamond DA 40 aircraft. The display functionality is supported by Microsoft Flight Simulator FSX and ESP. The hardware is produced from quality ABS using plastic injection moulding and high quality electronics (see Fig. 5).

A complete TRC1000 system includes two main displays and one Audio Panel. The high resolution TFT screens of the PFD and MFD displays are connected to additional video ports on the flight simulator PC.

The MFD and PFD displays each have a single USB connection, which provides a data highway through which the control of the knobs, pushbuttons, SD Card interfaces and the video information is channelled (Simkits, 2011).

We have found these devices to be robust although there were initially problems with first generation video controllers embedded in the devices. With an upgrade to second generation video controllers the units have performed flawlessly over the last six months of operation.

Nevertheless with more increased utilisation for research and training they will be closely monitored as to their reliability under repeated-use training. The cost of these units plus the audio controller was approximately $16,000. This compares favourably with the overall cost of a commercial Garmin Desktop trainer which retails for $30,000.

Figure 5: PCATD Glass Cockpit Primary Function Display (PFD)

Garmin simulated software

Flight1 Aviation Technologies has recently developed a G1000 Student Simulator software package that interfaces with Microsoft Flight Simulator X and Microsoft ESP.

The Flight1 Tech G1000 Student Simulator was coded to be used for real-world flight training in an immersive training experience. It also seamlessly integrates with the Simkits TRC 1000 Garmin hardware (Flight 1 Aviation Technologies, 2011). Other Garmin G1000 simulations that have been developed for Flight Simulator X and ESP (e.g. Mindstar Garmin Software) have much more limited functionality. Another advantage of Flight 1 Garmin software is that it is a stand-alone application which can be run remotely through a PC based network. The software team have produced a software application that has a high level of compatibility and functionality with a real–world Garmin 1000 glass cockpit suite

Automatic flight control system (AFCS)

The Flight 1 Aviation Technologies Garmin 1000 Student (G1000) Simulator includes an accurate simulation of the Garmin GFC 700 digital Automatic Flight Control System (AFCS) that realistically models the Flight Director and Autopilot. Also Flight Director Annunciations and Autopilot status are displayed on the PFD.

Vertical modes modelled include:

- Pitch Hold Mode (PIT)
- Selected Altitude Capture Mode (ALTS)
- Altitude Hold Mode (ALT)
- Vertical Speed Mode (VS)
- Flight Level Change Mode (FLC)
- Vertical Navigation Modes (VPTH, ALTV)
- Glide path Mode (GP)

- Glideslope Mode (GS)

Lateral modes modelled include:
- Roll Hold Mode (ROL)
- Heading Select Mode (HDG)
- Navigation Modes (GPS, VOR, LOC)
- Approach Modes (GPS, VAPP, LOC)
- Back course Mode (BC)

A stand-alone Failure Generator application can be connected to the G1000 Student Simulator software to provide an instructor with the ability to fail specific components of the G1000 display (including Airspeed, Altitude, Heading, Attitude, Vertical Speed, Nav Radio, Com Radio, Transponder, and RAIM). When failed, each component will display appropriate failure flags and /or visual indications (Flight 1 Aviation Technologies, 2011).

The MFD software includes Waypoint, Navigation, and Nearest page groups, as well as Direct To, Flight Plan, and Procedure functionality Flight plans can be created, saved, and loaded.

Instrument approaches

The G1000 Student Simulator also features an updatable worldwide navigation database. This is provided by a third party company called Navigraph which provides a monthly updated Aeronautical Information Regulation and Control (AIRAC) cycle of instrument approach data. This Navigraph database mirrors the Jeppesen database (real-world Garmin database) to a certain extent but is not as comprehensive.   The Navigraph contains 12,500 airports of which 3,751 airports contain complete instrument approaches. The cost of the Navigraph yearly subscription is only 20 Euro (13 AIRAC cycles) and although the database is expanding each year it may take some time before it models all 49,000 of the world's airports (Navigraph, 2011).
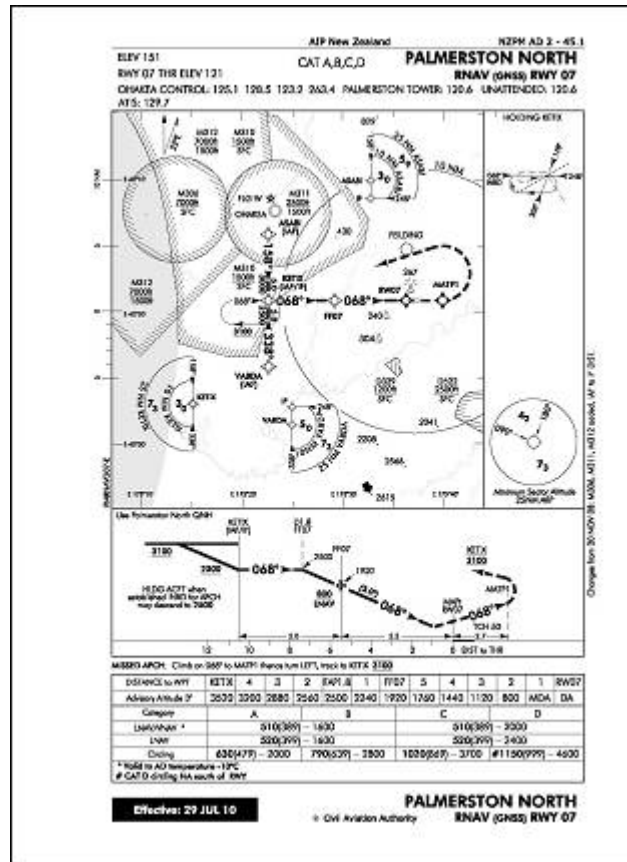
One drawback with the Navigraph database is the limited instrument approach data for New Zealand airports (NZAA, NZWN, NZCH, NZDN, and NZPM). This has meant that instrument approach data had to be generated for local airports such as Ohakea, Wanganui, Paraparaumu, Masterton, and Hawera.

Also a few of the New Zealand instrument approaches that currently exist in the database needed some refining, especially VOR/DME approaches. For example NZPM has one of the most complex VOR/DME approaches in the country and the current approach data needed to be revised[3].

An example of a Navigraph instrument approach format is outlined in Appendix 1. A sample of generated code for RNZAF Ohakea is outlined in Appendix 2. A comparison between the two appendices indicates how the approach transitions and final approaches are constructed Despite the clarity of the Navigraph database format the development of customised instrument approaches has not been straightforward. The G1000 software utilises the FSX autopilot engine and there are some well known issues with this autopilot engine. One example is the NZPM VOR/DME approach (see Fig. 6)

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[3] To assist in this area, Steve Hall, a current Air New Zealand 747 pilot was co-opted to assist with this project. Steve has a lot of experience in approach code theory and has assisted the NZ Flight Simulator Community with various projects involving improving NZ instrument procedures in MSFS.

Figure 6: Palmerston North RNAV Approach

In this approach the G1000 software Auto pilot (AP) will instigate a right hand turn into terrain after the missed approach point MATP1. There is a flaw in the FSX auto pilot engine that sometimes appears when completing a 180 degree turn. In this special case the AP will turn the wrong way even though the correct turn direction is specified in the Navigraph database. This kind of flaw can undermine the training of an instrument approach procedure and therefore practical solutions have to be found.

In this scenario a precisely placed dummy waypoint to the left of the missed approach point MATP1 will coax the AP engine to turn left back to the KETIX waypoint and the holding pattern. Nevertheless this is a compromise as the dummy waypoint will be listed in the MFD approach list.

A unique labeling system by which the student pilot can recognise such dummy waypoints in the PCATD will help them to realize that they will not necessarily exist in the real-world Garmin. This should not be too much of an issue as the Jeppesen database (used in real-world Garmins) for NZ instrument approaches also has a number of discrepancies. A certain amount of latitude is required when comparing the official Airways approach plates with the two different databases (Jeppesen, Navigraph).

Other areas that limit the complexity of instrument approaches that can be displayed relate to the type of Transition Approach legs the G1000 software can process. These legs are not supported by the G1000 software (Garmin, 2011):

- CD – Course to a DME distance
- CI – Course to an intercept

- CR – Course to a radial
- VA – Heading vector to an altitude
- VD – Heading vector to DME distance
- VI – Heading vector to an intercept
- VM – Heading vector to manual termination
- VR – Heading vector to a radial

Despite these limitations virtually all SID, STAR, RNAV, ILS, NDB, and VOR/DME approaches can be accurately simulated with a combination of G1000 software and an accurate Navigraph database file for the particular approach.

Diamond DA 40 limitations

The PCATD design includes a 2 DOF motion platform, three 37 inch LCD visual displays, and a fully functional cockpit, combined with a networked instructor station. A design flowchart is outlined in Appendix 3.

Due to budgetary constraints the flight controls do not incorporate expensive force feedback systems. Instead they are directly linked to potentiometers that connect directly to a Haagstrom Keyboard/Joystick Interface Board. Although there is no force feedback on the flight controls the rudder pedals are dampened with small air shock absorbers. Also bungees and a friction screw are attached to the control column to provide some feeling of resistance. The primary aim of this PCATD was procedural training and due to the low fidelity of the flight controls, teaching pure flying skills is not a viable option,

Nevertheless there is sufficient response in the flight controls to teach basic maneuvering that would be necessary to maintain height and bearing when related to instrument approach training. A research project has been commenced to look at cost effective ways of developing a force feedback system driven either by electrical servos or magnetic fields.

The visual displays are high resolution and provide a wide aspect of more than 120 degrees. However they do not provide depth perception for visual scenes as well as full flight simulators can, with their inbuilt collimated displays. New developments in 3D LCD displays may provide a cost effective answer to providing depth perception for low cost PCATD's.

Discussion

The development of these two PCATD's for quite diverse training purposes and their subsequent certification by CAA has demonstrated the potential these devices have for aviation training in New Zealand. Traditionally FTD's and PCATD's have been sourced from overseas based companies, and they represent a considerable financial investment for NZ flying training organisations. The cost of these devices is generally beyond the financial resources of most small to medium sized flying schools in NZ. The development of cost effective PCATD's are a viable alternative for these flying training schools. Also they provide a greater degree of flexibility and versatility by utilising COTS hardware and software. Because of the COTS philosophy, the upgrading of these PCATD's is also less costly and can be conducted more frequently. Aviation training is facing significant fiscal constraints as well as increasing demands to accurately simulate complex glass cockpit systems found in modern GA aircraft. The adoption of this type of PCATD technology could well be an effective solution to these difficult challenges.

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Appendix One – Navigraph Format Excerpt

11. APPROACH TRANSITION
1 APPTR Record identifier string 5 always APPTR
2 ANE4L Approach identifier string 10
3 07L Runway identifier string 3
4 RID Transition fix string 5 Initial Approach Fix

12. FINAL APPROACH
1 FINAL Record identifier string 5 always FINAL
2 ANE4L Approach identifier string 10
3 07L Runway identifier string 3
4 C Approach type string 1 see Approach Types below

13. WAYPOINT TYPE IF (Initial Fix)
1 IF Record identifier string 2 x always IF
2 REDGO Waypoint identifier string 5 x
3 50.10916669 Waypoint latitude double x degrees

4 8.85638906 Waypoint longitude double x degrees
5 TAU Navaid identifier string 5
6 69.0 Waypoint bearing double degrees
7 0.0 Waypoint distance double nautical miles
8 1 Altitude constraint int see Altitude Constraints below
9 4000 First altitude int feet
10 0 Second altitude int feet
11 1 Speed constraint int see Speed Constraints below
12 160 First speed int knots
13 0 Second speed int knots
14 0 Special Waypoint int see Special Waypoints below
15 0 Overfly Waypoint bool see Overfly Waypoints below
16 0 Missed Approach Fix bool

14. WAYPOINT TYPE TF (Track to a Fix)
1 TF Record identifier string 2 x always TF
2 REDGO Waypoint identifier string 5 x
3 50.10916669 Waypoint latitude double x degrees
4 8.85638906 Waypoint longitude double x degrees
5 0 Turn direction int see Turn Directions below
6 TAU Navaid identifier string 5
7 69.0 Waypoint bearing double degrees
8 0.0 Waypoint distance double nautical miles
9 249 Magnetic course int degrees
10 4.3 Distance double nautical miles
11 1 Altitude constraint int see Altitude Constraints below
12 4000 First altitude int feet
13 0 Second altitude int feet
14 1 Speed constraint int see Speed Constraints below
15 160 First speed int knots
16 0 Second speed int knots
17 0 Special Waypoint int see Special Waypoints below
18 0 Overfly Waypoint bool see Overfly Waypoints below
19 0 Missed Approach Fix bool

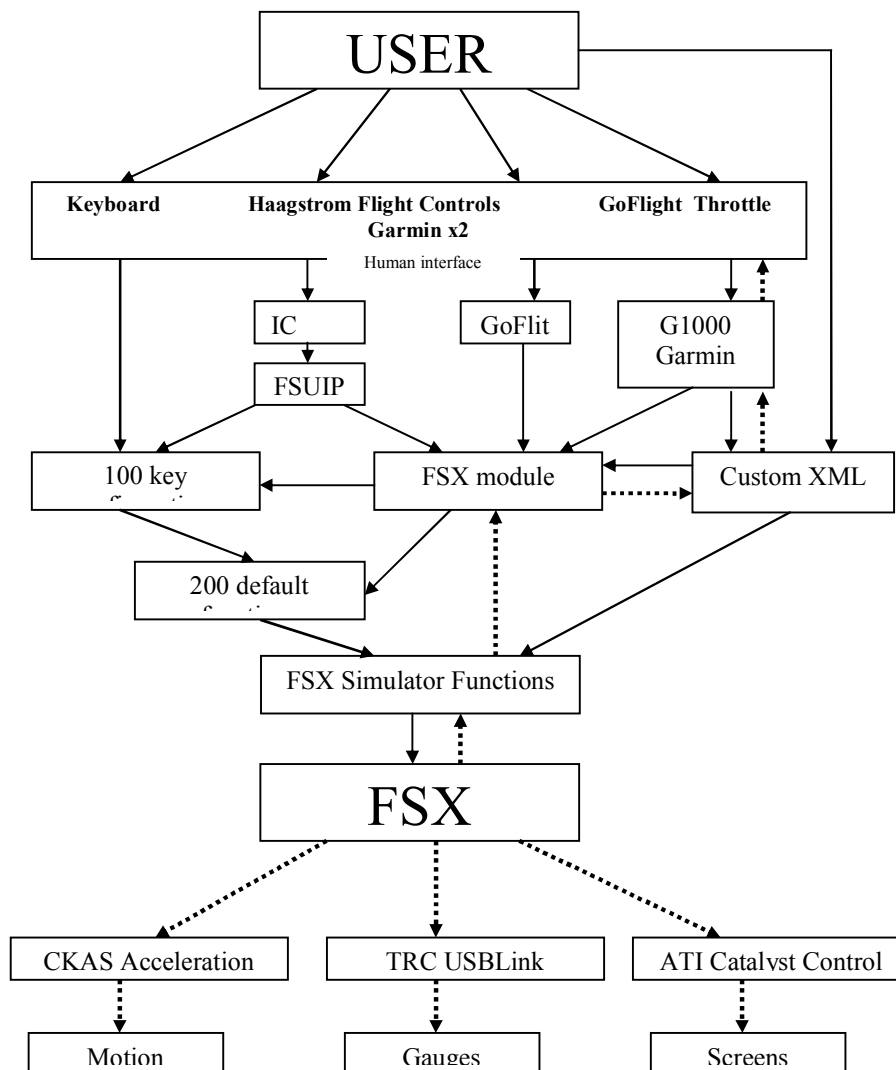## Appendix Two – Example of partially generated code for NZOH

```
APPTR,I09,09,D160O
IF,D160O,-40.459703,175.383400, ,160.0,15.0,0,0,0,1,0,0,0,0
AF,D268O,-40.12086,175.084909,2,OH,108.0,15.0,360.0,2,4000,0,1,0,0,0,0
TF,DME10,-40.149299,175.187521031,2,IRM,0.0,0.0,0.0,0.0,0.0,2,2300,0,1,0,0,0,0

APPTR,I09,09,D360O
IF,D360O,-39.976614,175.511208, ,360.0,15.0,0,0,0,1,0,0,0,0
AF,D268O,-40.12086,175.084909,1,OH,092.0,15.0,360.0,2,4000,0,1,0,0,0,0
TF,DME10,-40.149299,175.187521031,1,IRM,0.0,0.0,0.0,0.0,0.0,2,2300,0,1,0,0,0,0

APPTR,I09,09,OH
IF,OH,-40.209611,175.391972, ,0.0,0.0,0,2,4000,0,1,0,0,0,0
CD,OH,-40.209611,175.391972,0,OH,0.0,0.0,0,242.0,10.0,2,2300,0,1,0,0,0,0
TF,DME10,-40.149299,175.187521031,2,IRM,0.0,0.0,0.0,0.0,0.0,2,2300,0,1,0,0,0,0
```

16

```
FINAL,I09,09,I,3
IF,DME10,-40.149299,175.187521031,IRM,0.0,0.0,1,2300,2300,1,0,0,0,0
CF,FF09,-40.168963,175.255116,0,IRM,0.0,0.0,88.0,2.3,1,2300,0,1,0,0,2,0
CF,RW09,-40.202650,175.374228,0,IRM,0.0,0.0,88.0,6.5,1,200,0,1,0,0,3,1
CA,0,88.0,2,1200,0,1,0,0,0,0
//VI,1,OH,360.0,330.0,0,0,0,1,0,0,0,0//
TF,MA1,-40.162266,175.416094309,1, ,0.0,0.0,0.0,0.0,0,0,1,0,0,0,0
CF,D360K,-40.038758,175.478653,2,OH,0.0,0.0,360.0,11.0,1,3300,0,1,0,0,0,0
HM,D360K,-40.038758,175.478653,2,OH,0.0,0.0,360.0,3.0,2,3300,0,1,0,0,0,0
```

Appendix Three – Design Flowchart of Diamond DA 40 PCATD

REWETI S, A GILBEY, L JEFFREYS and S HALL (2011). *PC-based aviation training devices (PCATDs): research, development and certification.* Aviation Education and Research Proceedings (ISSN 1176-0729), vol 2011, pp 5-18.

Appendix Four – Auckland Rescue Helicopter Trust PCATD certification

4. Approved Purposes:

Purposes:

(a) Two hours instrument ground time towards the issue of a Private Pilot Licence - Helicopter (AC61-3, Appendix I);

(b) Five hours instrument ground time towards the experience requirement for night cross country by a Commercial Pilot Licence - Helicopter (AC61-5, Appendix I);

(c) Five hours instrument ground time towards the issue of a Category C or B Flight Instructor Rating - Helicopter (AC61-18, Appendix I);

(d) Twenty hours instrument ground time towards the issue of an Instrument Rating - Helicopter (AC61-17),

(e) Two hours of instrument ground time towards the currency requirements of an Instrument Rating - Helicopter [CAR Part 61.807 (a)(2)(i)];

(f) One GNSS, NDB, VOR, LLZ or ILS approach procedure toward the currency requirements of an Instrument Rating - Helicopter [CAR Part 61.807(a)(2)(ii)];

(g) One GNSS, NDB, VOR, LLZ (non-precision) or ILS (precision) approach procedure toward approach currency requirements of an Instrument Rating - Helicopter in any one 3 month period [CAR Part 61.807(a)(4)];

(h) Conduct of the cross-country portion and any one approach of every alternate Instrument Rating Annual Competency Demonstration - Helicopter [required by CAR Part 61.801(a)(6)].

Synthetic Training Device - Purposes And Conditions - Auckland Regional Rescue Helicopter Trust

5. Approved Conditions:

This approval is subject to the following conditions:

1. Each instructor shall be specifically approved by Auckland Regional Rescue Helicopter Trust for the purpose of instructing on the ARHTsim09 in accordance with the company's Synthetic Flight Trainer Manual (SFTM);

2. Each instructor shall hold a current flight instructor rating in respect of approvals (a), (b) and (c) and a current instructor rating and current instrument rating helicopter in respect of approvals (d), (e), (f) and (g), and current flight examiner rating privileges in respect of approval (h); Neither instructor nor examiner need maintain a current medical certificate for training or examining in the simulator;

3. The device shall be maintained to a level where it can meet the specific performance tasks required of it and in accordance with the company's SFTM;

4. Instruction details and times shall be entered in the candidate's logbook as instrument ground time, and each entry signed by the approved instructor who gave the instruction;

5. This certificate shall be displayed in the vicinity of the trainer for public viewing.

Unless either surrendered by the holder or suspended or cancelled by notice in writing from the Director this certificate shall remain in force until 15 September 2012.

Appendix Five – Diamond DA 40 PCATD certification

Synthetic Training Device - Purposes And Conditions - Massey University School of Aviation

3. Permitted to use the following STD:

Massey University School of Aviation Diamond DA40 Replica S/N 046878-2

4. Approved Purposes:

Purposes:

(a) Two hours instrument ground time towards the issue of a Private Pilot Licence - Aeroplane (AC61-3, Appendix I);

(b) Five hours instrument ground time towards the issue of a Commercial Pilot Licence - Aeroplane (AC61-5, Appendix I);

(c) Five hours instrument ground time towards the issue of a Category C or B Flight Instructor Rating - Aeroplane (AC61-18, Appendix I);

(d) Ten hours instrument ground time towards the issue of an Instrument Rating - Aeroplane (AC61-17);

(e) Two hours of instrument ground time towards the currency requirements of an Instrument Rating - Aeroplane [CAR Part 61.807 (a)(2)(i)];

(f) One RNAV(GNSS), NDB, VOR, LLZ or ILS approach procedure toward the currency requirements of an Instrument Rating - Aeroplane [CAR Part 61.807(a)(2)(ii)];

(g) One RNAV(GNSS), NDB, VOR, LLZ (non-precision) or ILS (precision) approach procedure toward approach currency requirements of an Instrument Rating - Aeroplane in any one 3 month period [CAR Part 61.807(a)(4)];

(h) Demonstration of Garmin 1000 GNSS as a subsequent type and model (AC61-17, Appendix II).

5. Approved Conditions:

This approval is subject to the following conditions:

1. Each instructor shall be specifically approved by Massey University School of Aviation for the purpose of instructing on the Massey University School of Aviation Diamond DA40 Replica in accordance with the company's Synthetic Flight Trainer Manual (SFTM);

2. Each instructor shall hold a current flight instructor rating in respect of approvals (a), (b) and (c) and a current instructor rating and current instrument rating aeroplane in respect of approvals (d), (e), (f) and (g), and current flight examiner rating privileges in respect of approval (h): Neither instructor nor examiner need maintain a current medical certificate for training or examining in the simulator;

3. The device shall be maintained to a level where it can meet the specific performance tasks required of it and in accordance with the company's SFTM;

4. Instruction details and times shall be entered in the candidate's logbook as instrument ground time, and each entry signed by the approved instructor who gave the instruction;

5. This certificate shall be displayed in the vicinity of the trainer for public viewing.

Unless either surrendered by the holder or suspended or cancelled by notice in writing from the Director this cert

Accepted By: .... Dated 17 May 2011

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Evidence based training for airline pilots

Patrick S. MURRAY[*]

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Abstract

The progress in design and reliability of modern aircraft, together with a rapidly changing operational environment has prompted a review of airline pilot training. Despite initiatives over the past 30 years, there is a growing recognition that still not enough has been done to address human factors issues. Analysis of accident and incident reports, flight data together with other robust data sources such as LOSA, will allow the identification of risks encountered in actual operations and the ability to tailor training programs to mitigate these real risks. This presentation details a current project that is sponsored by the International Air Transport Association, the aim of which is to identify, develop and train the knowledge, skills and attitudes required to operate safely, effectively and efficiently in an airline environment. An analysis of the most relevant threats, through evidence collected in flight operations and training, can drive regulatory change and enable the worldwide implementation of more effective training standards to improve operational safety. The outcome will be to inform continuous improvement in ICAO standards, recommended practices and guidance material.

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T-Visual Approach Slope Indicator System (T-VASIS) versus Precision Approach Path Indicator (PAPI) – the debate revisited.

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Abstract   *Two visual approach slope indicator lighting systems are in use in Australasia. These systems are designed to ameliorate and overcome the visual illusions associated with the approach and landing manoeuvre of aircraft. Using a flight simulator, 14 student pilot candidates, with little actual flying experience, 'flew' 10 approaches using PAPI and 10 approaches using T-VASIS. The approaches were 'flown' in various flight conditions including low visibility. The visual approach slope indicator lighting system was randomly assigned to each experimental condition. Results indicated that overall, there was less deviation from a correct glidepath when the approaches were 'flown' using T-VASIS. A post-flight survey indicated that participants found T-VASIS to be more intuitive. The results are discussed with reference to the prevailing preference of PAPI over T-VASIS by aviation authorities.*

Introduction

Statistically, the approach and landing phases of flight are considered to be the most dangerous with a high percentage of aircraft accidents occurring during these phases (Clark and Antonenko, 1993, p.49). Visually maintaining the correct approach path just prior to landing can be a demanding exercise in conditions of poor visibility, in rain and at night. Such demands on the pilot can be compounded by making the approach to land onto a runway with an up-slope or down-slope or by flying into an approach area with little foreground lighting or no ambient light – the black-hole approach, (Hawkins, 1993).

Visual approach slope indicator lighting systems can help the pilot overcome the visual illusions that might otherwise result in an undershoot or overshoot situation in the final stages of the approach to land. In Australasia, there are two approach slope lighting guidance systems: the T-Visual Approach Slope Indicator System (T-VASIS) and the Precision Approach Path Indicator (PAPI), (Nolan, 2005). While both systems are approved for use by the International Civil Aviation Organisation (ICAO), according to Clark (1999) the T-VASIS system is under a threat of obsolescence because the colour-coded United Kingdom PAPI system is cheaper to install and maintain. However, Clark (1999) also reports that pilots familiar with the Australian-developed T-VASIS system generally praise it.

T-Visual Approach Slope Indicator System (T-VASIS)

The T-VASIS consists of 20 lights with 10 placed either side of the runway centre line in the form of two wing bars of four lights each with bisecting longitudinal lines of six lights. The pilot on glideslope will see a horizontal line of four white lights. When above the slope the pilot will see an inverted white 'T' with one, two or three white 'fly

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down' lights visible. The higher the aircraft is above the correct slope the more 'fly down' lights are visible.

The correct 'standard' slope is three degrees [2.97°] with an eye height of 15 metres over the runway threshold. When installed at a runway with an Instrument Landing System (ILS), the approach slope indicator is compatible with that of the ILS, (Nolan, 2005, p.32).

When below the correct approach slope the pilot will see a white 'T' and the lower the aircraft is below the correct slope the more 'fly up' lights will be visible. When well below the approach slope the pilot will see the three longitudinal lights in the 'T' as red. (See figure 1.)
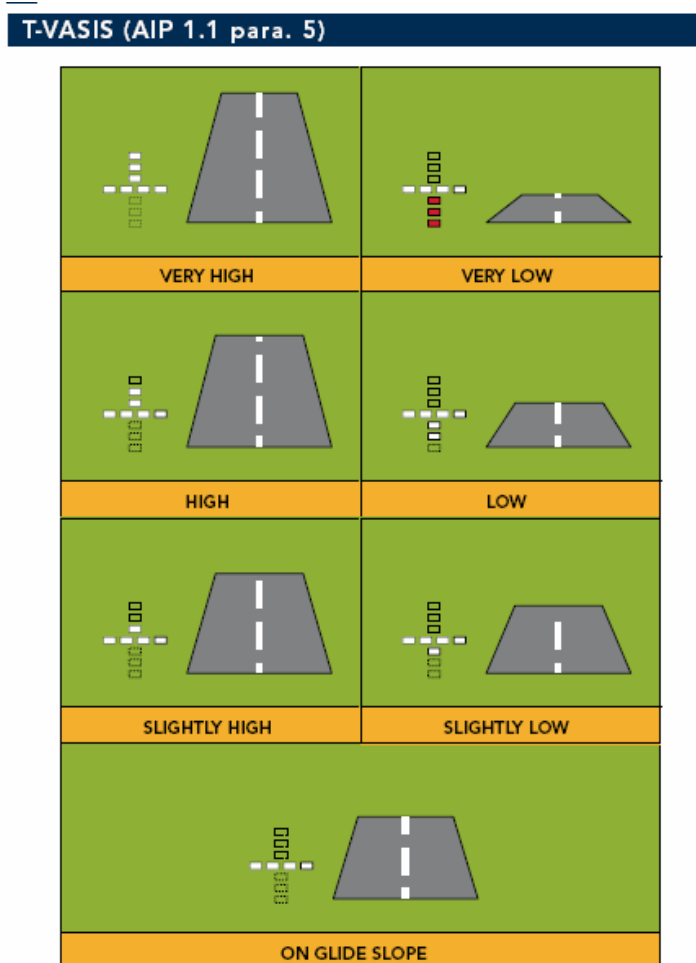

Figure 1. T-VASIS displayed indicators. (Civil Aviation Safety Authority, 2010 p. 228)

Precision Approach Path Indicator (PAPI)

PAPI is made up of four equally spaced sharp transition multi-lamp lights, mounted horizontally as a 'wing bar' on the left-hand side of the runway as viewed on approach. On the correct approach slope the pilot will see the two lights closest to the runway as red and the two lights farthest from the runway as white. If above the correct approach slope the pilot will see the light closest to the runway as red and the other three lights as white. If further above the correct slope the pilot will see all lights as white.

If below the correct approach slope the pilot will see the three lights closest to the runway as red and the farthest as white. If well below the correct approach slope the

pilot will see four red lights. As with the T-VASIS system, when the runway has an ILS, the PAPI must have the same approach angle as the ILS and be located to achieve the same threshold wheel crossing height, (Nolan, 2005, p.33). (See figure 2.)
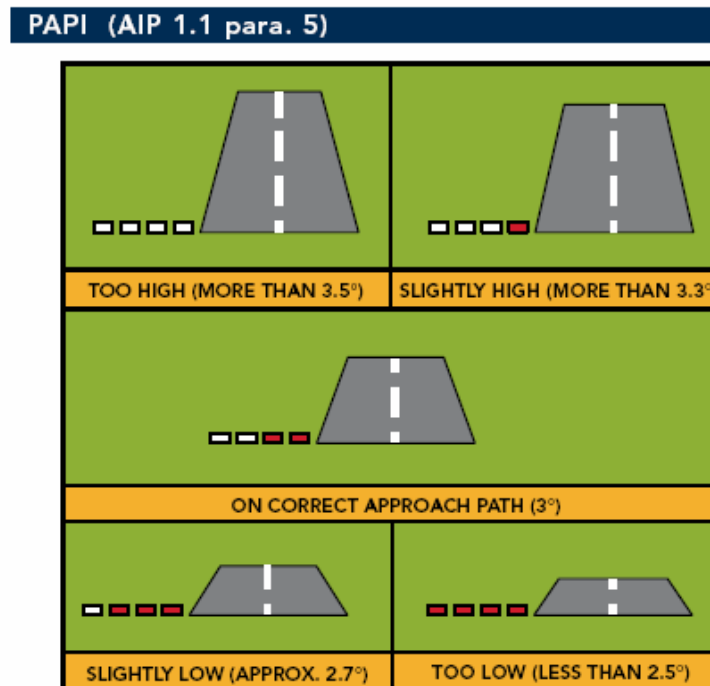

Figure 2. PAPI displayed indicators. (Civil Aviation Safety Authority, 2010 p. 229)

In the 1950's much work was carried out at the Aeronautical Research Laboratories in Melbourne to compare the relative efficacy of the Farnborough-developed Angle-of-Approach Indicator; the Red-White system; the Precision Visual Glidepath system and the Tee Visual Glidepath (TVG) system. The last evolved into the T-Visual Approach Slope Indicator System (T-VASIS), (Day, 1999). According to Day (1999) some 50 pilots and non-pilot observers were bussed to the top of a small mountain range adjacent to Avalon airport (not far from Melbourne) where they were asked to respond to misalignments in the visual indicator systems on the Avalon runway.

Testing of the various approach indicator lighting systems was also carried out by ground observers. These ground observers used theodolites to track and record aeroplanes on approach. This work also involved the subjective assessments of the Lockheed Electra flight crews as they performed the many approaches to land, (Day,1999).

Day (1999) reported that the Tee Visual Glidepath (the precursor of T-VASIS) performed better than the two other systems in terms of both objective theodolite measurements and subjective assessments by the pilots.

Millar (1984) carried out an analytical comparison of the three Visual Approach Slope Indicators (VASIs) approved by the International Civil Aviation Organisation (ICAO) for use by turbojet aeroplanes: VASIS, T-VASIS and PAPI. Millar (1984) used published performance data including approach path measurements and pilot opinion and found that the T-VASIS is a more precise and sensitive aid than the red-white VASIS system. Millar (1984) postulated that, based on the relative performance of the VASIS and T-VASIS and the problems associated with the red-white VASIS system, PAPI would perform less satisfactorily than T-VASIS. Millar (1984) suggested that

PAPI be evaluated using objective measures in a controlled experiment with transport aircraft.

The present study was carried out using a flight simulator in order to determine if there is a difference in pilot ability to follow a correct glidepath using two different visual approach slope indicator lighting systems. Also, a subjective measurement of pilot preference in the use of T-VASIS and PAPI was obtained in order to determine if pilots of limited flying experience shared the same views regarding the intuitive nature of PAPI versus T-VASIS as reported in the literature by industry pilots.

The hypothesis predicted that, under similar conditions of low visibility, the approaches made using T-VASIS would be more accurately flown than the approaches made using PAPI. It was also hypothesised that pilots of limited flying experience would prefer the T-VASIS system over the PAPI system.

Methods

Subjects: The participants in the present study were 14 third-year aviation students from UNSW (Canberra). The ages of the subjects ranged from 20 to 23 years with a mean of approximately 21 years. The subjects all had a minimum of 21 flying hours. Several had logged some 40 to 50 hours but under the terms of their cadetships, no-one had flown an actual aircraft in the preceding two and a half years. The participants had no experience of visual approach slope indicator lighting systems. This study was conducted in accordance with ethics approval granted by UNSW (Canberra) Human Research Ethics Advisory Panel.

Design: Each subject made 20 approach-to-land manoeuvres in a Beechcraft King Air 350 flight simulator using *Microsoft Flight Sim 2004*. 10 approaches were made using T-VASIS onto runway 19 at Brisbane and 10 approaches were made using PAPI onto runway 05 at Adelaide. These two runways were selected as they are of a similar dimension and also involved approaches over water devoid of visual cues. Visual cues relating to different runway aspect and foreground stimuli were therefore minimised. The order of the visual approach slope indicator lighting system was randomly assigned so that, in each of the flight conditions described below, a T-VASIS approach would be followed by PAPI approach and then vice-versa.

The dependant variable was deviation from the correct approach path. Such deviation was recorded by the flight simulator recorder function every second of each flight sequence.

Apparatus: The study was conducted in the Aviation Studio located at the School of Engineering and Information Technology; University of New South Wales (Canberra). The flight console has interchangeable throttle quadrants such that flight can be simulated in aircraft ranging from single-engine piston aircraft to heavy four-engine transport jets. (See figure 3.) The software used was Microsoft Flight Simulator 2004.

The apparatus for measuring the degree of pilot preference for each visual approach slope indicator lighting system was a post-flight questionnaire. The questionnaire is attached as appendix B.

Figure 3 The Aviation Studio showing the Flight Console and the three-screen projected image

Procedure: Participants 'flew' a practice approach in conditions of unlimited visibility (CAVOK) by day from a position aligned with the centre line of the runway at a distance of three nautical miles from the runway threshold and at an altitude of 1000 feet. This practice approach was followed by a sequence of eight approaches made in various conditions of visibility and starting positions. The starting position of the approach-to-land manoeuvres was manipulated so that some approaches started at 1500 feet (high) and some approaches started at from the low position of 500 feet. The approach flight conditions were: night, CAVOK and on slope at three nautical miles; day, CAVOK and starting low; day, CAVOK and starting high; night CAVOK and starting low; night CAVOK and starting high; day through heavy rain and turbulence; night through heavy rain and turbulence; fog such that visibility was reduced to three nautical miles. The final approach [number 10] was made in day CAVOK flight conditions from an offset position so that at the completion of a turn the aircraft could be ideally positioned on final at three nautical miles. Before each approach each participant was briefed as to what approach they might expect; the flight conditions, the starting point as well as the visual approach slope indicator lighting system in use for the approach.

Results

The deviation from the correct approach flight path was recorded by the flight simulator recorder function every second of each flight sequence. An example of an individual participant's flight trajectories for each visual approach lighting system is shown in Appendix A.

The flight simulator deviation measured the parameters of distance to the runway threshold and altitude. A mean angle of error was calculated for each flight condition and the results for all the participants were averaged for each flight condition. The resultant data is shown in table 1.

Table 1. The means of all angular deviations from the correct approach slope for each flight condition and each visual approach lighting system.

	1 Day	2 Night	3 Low	4 High	5 Night Low	6 Night High	7 Rain & Turb	8 Night Rain & Turb	9 Fog	10 Offset	Mean 1-10
PAPI	0.51	0.47	0.59	0.79	0.71	0.82	0.57	0.62	0.46	0.47	0.60
T-VASIS	0.43	0.46	0.61	0.63	0.59	0.72	0.47	0.52	0.53	0.45	0.54

The deviation from the correct approach flight path was less when T-VASIS was the visual approach lighting aid used. The exceptions were for flying condition 3 [day, CAVOK starting low] & 9 [fog, vis. 3NM]. Overall, the mean of the means of the angle of error for each flight condition indicated that T-VASIS produced less deviation from the correct approach flight path. (The results shown in table 1 were graphed and appear as figure 4.)
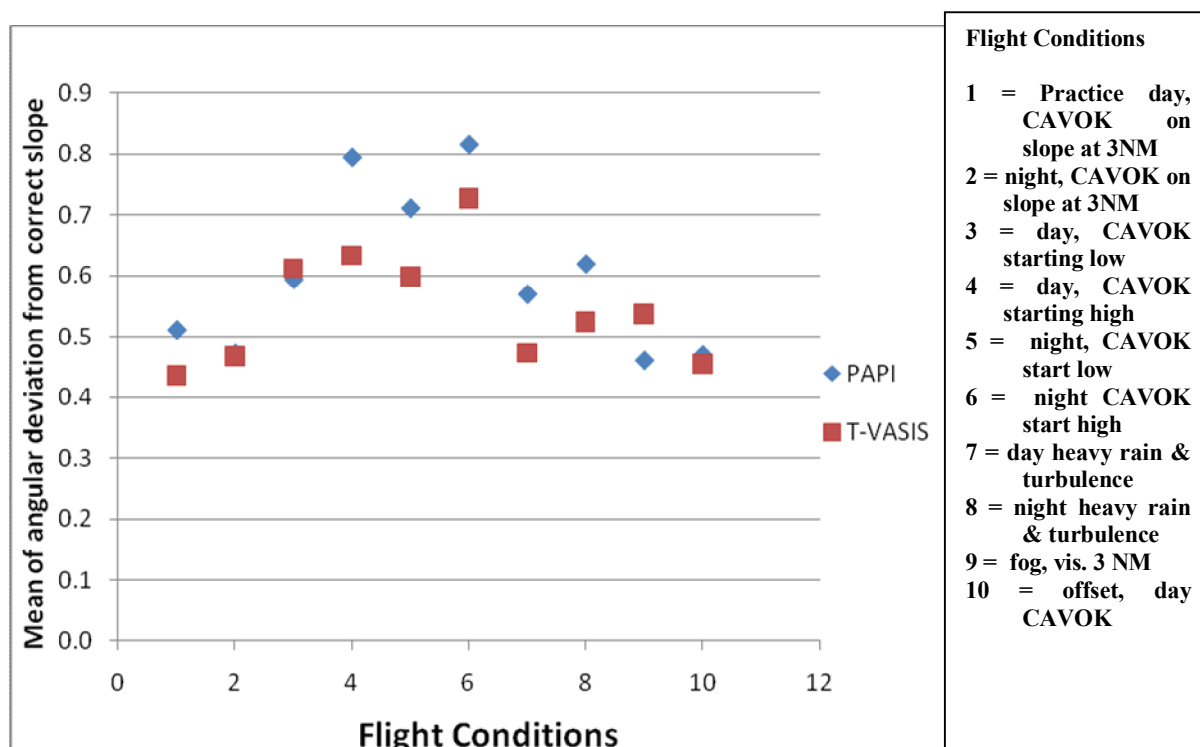

Flight Conditions

1 = Practice day, CAVOK on slope at 3NM
2 = night, CAVOK on slope at 3NM
3 = day, CAVOK starting low
4 = day, CAVOK starting high
5 = night, CAVOK start low
6 = night CAVOK start high
7 = day heavy rain & turbulence
8 = night heavy rain & turbulence
9 = fog, vis. 3 NM
10 = offset, day CAVOK

Figure 4. Means of angular deviation from the correct slope for the 10 approach flight conditions using PAPI and T- VASIS.

The answers to the questionnaire regarding preferred visual approach lighting system were answered either 'T-VASIS' or 'PAPI'. The responses appear in Appendix C. The total number of responses favouring T-VASIS were summated and calculated as a percentage of all responses. PAPI favourable responses were treated in the same manner. A pie-chart showing the percentage of total responses regarding preferred visual approach lighting system is show in figure 5.
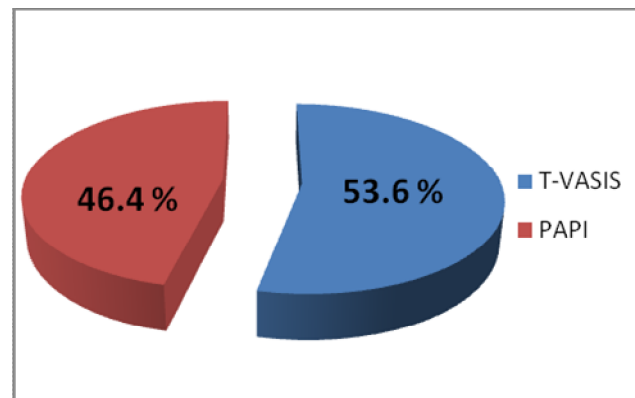
Figure 5. Result of the four-question post-flight survey indicating overall percentage of preference for T-VASIS or PAPI as a visual approach-slope indicator lighting system.

53.6% of all the responses to the questionnaire regarding preferred T-VASIS as a visual approach lighting system. However, in response to the last question: 'Which system did you prefer to use?'; the majority [64%] answered PAPI.

Discussion

The results supported the hypothesis that visual approaches made using T-VASIS would be more accurately flown than the approaches made using PAPI. The results are in accordance with the findings of Day (1999) who used objective theodolite measurements to measure the relative accuracy of three visual glidepath systems.

The results partially supported the hypothesis that pilots of limited flying experience would prefer the T-VASIS over the PAPI system. The results are generally in accordance with Day (1999) who found that pilots' subjective assessments rated T-VASIS more highly than PAPI. The present study deliberately selected participants who had little exposure to flying in order to overcome the bias of experienced pilots that is reported in the literature. It is interesting to note that while a majority of participants in this study found that the T-VASIS as a visual approach system was more intuitive than PAPI however, a majority of participants indicated that they would prefer to use the PAPI system rather than the T-VASIS.

It is of interest to note that despite the objective measurements made by Day (1999) – measurements supported by this study - the use of T-VASIS, as an approach lighting system, is on the decline in Australia. The comments posted by pilots on the social networking website PPRUNE regarding the change from T-VASIS to PAPI on runway 34 at Melbourne International Airport bear testament to the general dislike of PAPI. Aircraft landing on runway 34 in Melbourne are usually held high at 2,500 feet due to the overflying of the adjacent Essendon Airport airspace. The subsequent aircraft descent onto a short final approach, onto a runway with a 2% up-slope is greatly aided by an effective visual approach aid.

This study has not focussed on the effect of each flying condition, [visibility, day/night etc], on the accuracy or otherwise of flying a visual approach using T-VASIS or PAPI. Rather, this study has considered overall results. Further work is indicated where hypotheses regarding the effect of specific flight conditions may elucidate the relative merits of T-VASIS and PAPI as aids to conducting accurate and safe visual approaches under varying levels of visibility.

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Appendix A

An individual participant's [A108] flight trajectories for each visual approach lighting system as recorded by the flight simulator
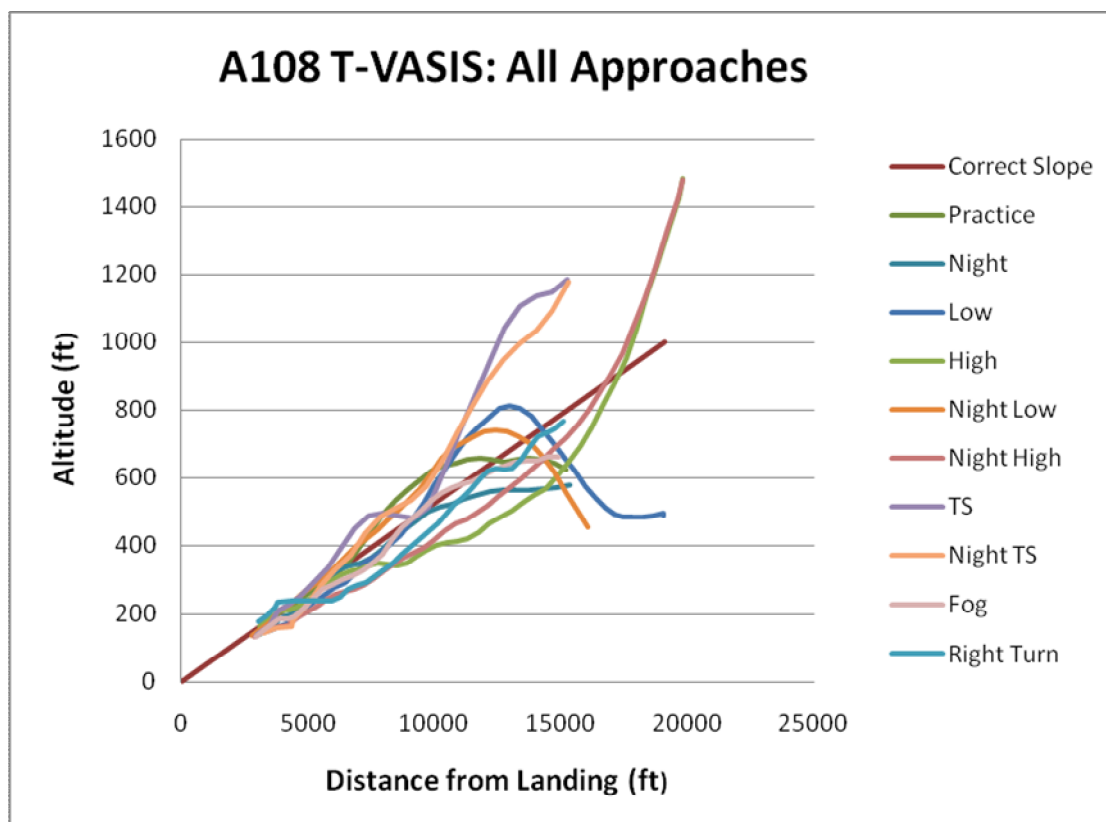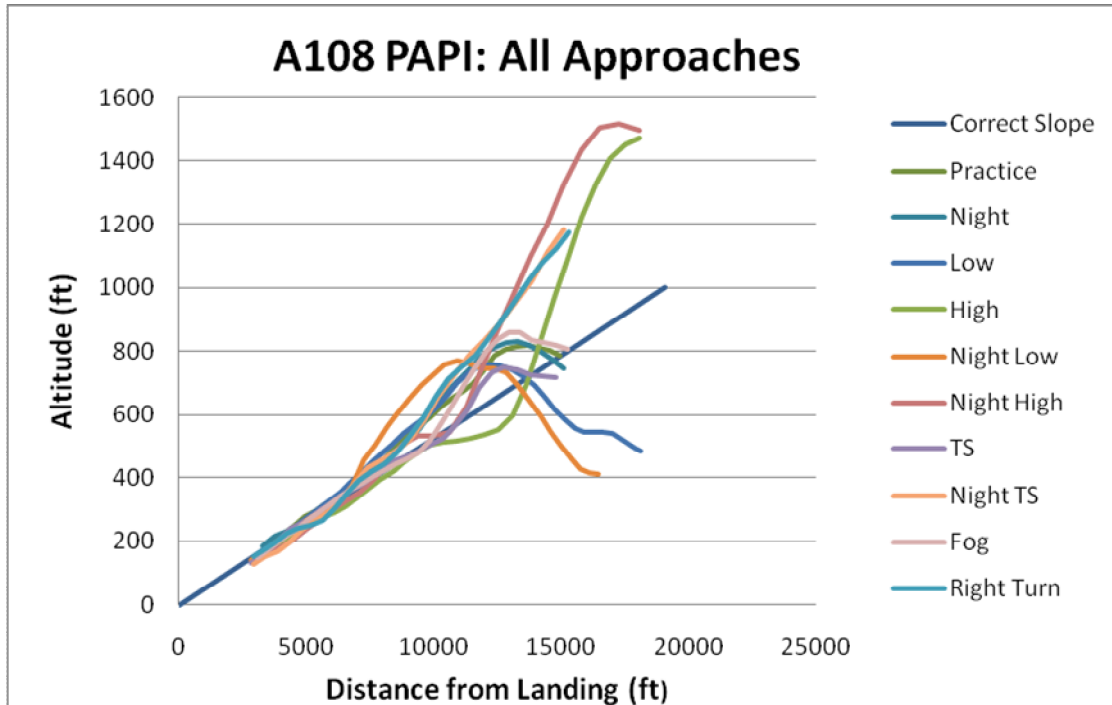
Appendix B

Participant Post-Flight Survey

Please circle your answer

Question 1. Which system you think best displays information where you intuitively believe that you are on the correct glide slope?

PAPI	T-VASIS

Question 2. Which system you think best displays information where you intuitively believe that you are above the correct glide slope

T-VASIS

PAPI

Question 3. Which system you think best displays information where you intuitively believe that you are below the correct glide slope (low)?

PAPI	T-VASIS

Question 4. Which system did you prefer to use?

T-VASIS	PAPI

Appendix C

Answers to the four questions on the post-flight survey where P = PAPI and T = T-VASIS

	Survey Questionnaire Question Number				
Subject	1	2	3	4	
A100	T	T	T	T	
A101	T	T	P	T	
A102	T	T	T	T	
A103	P	T	P	P	
A104	T	T	T	P	
A105	P	P	P	P	
A106	P	P	P	P	
A107	T	T	P	P	
A108	P	T	T	P	
A109	T	T	T	P	
A110	T	T	T	T	
A111	T	P	P	P	
A112	P	T	P	T	
A113	P	T	P	P	
Total T	8 T	11 T	6 T	5 T	30 T
Total P	6 P	3 P	8 P	9 P	26 P

Research into the implementation of the proposed New Zealand Civil Aviation Rule Part 115 – adventure aviation

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Massey University School of Aviation

Abstract. Research has been initiated in order to ascertain the processes and obstacles relating to the application of new regulation that applies to adventure aviation activities which have become commercialised. The development of the new regulation has lead to a notice of proposed rule (NPRM) making under the New Zealand Civil Aviation Authority (CAA) rule structure as New Zealand Civil Aviation Rule (NZCAR) Part 115 – Adventure Aviation. To date, the field research is currently underway and is expected to be completed by the time of the conference.

Introduction

New Zealand Civil Aviation Rule (NZCAR) Part 115 – Adventure Aviation captures a range of operations that commercialise airborne experiential activities and which cannot be considered to be "air transport" or flight training. It includes activities such as hang gliding, paragliding, microlight scenic flying, ballooning, and joyriding operations using vintage or ex military aircraft.

The regulation was developed due to a number of perceived problems:

1. The growth of the adventure aviation sector within an inadequately regulated environment.
2. The CAA's inability to regulate entry, facilitate surveillance and audit, or to control, restrict, or prohibit activities.
3. A number of accidents within the adventure tourism sector generally – including the adventure aviation sector – has attracted considerable media attention and there have been associated calls for appropriate regulation in order to improve safety.
4. A resulting public and industry demand for recognisable standards of quality and safety.

The development of the regulation itself faced a number of obstacles, such as defining what the applicable safety standards were. The range of activities require a common and realistic set of standards and one particular difficulty is how should a rule apply to such a variable set of activities that have a range of differing procedures and operational environments.

From the point of view of the regulator, the problems are:

- The integration of current and potential operations in to the traditional regulatory framework.
- The effective uptake of the provisions of the Rule.
- The establishment of entry and surveillance mechanisms.
- The development of safety indicators and the achievement of a demonstrable increase in safety for the sector.

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From the point of view of the operator the problems are:
- The extension of regulation into what have previously been considered to be sporting activities.
- The application of a single standard applicable to a very wide range of aerial activities.
- The implementation of novel best-practice systems to organisations possessing informal organisational structures and limited resources.

The research was instigated in order to indentify the key issues and suggest solutions. The research goals are to present an overall view of the rationale for the new regulation and the basis of safety regulation as it relates to commercialised recreational aviation in New Zealand.

Methodology

Sample

The field research consists of a survey of a range of operators across the spectrum of adventure aviation in order to ascertain their attitudes and opinions and to measure the actual level of compliance currently achieved and therefore what is required to enable compliance once the new Rule is promulgated. It utilises a qualitative assessment of the outcomes of a practical application of a developed best practice template upon the current systems used by operators.

The targeted participants are current operators of adventure aviation activities and other operators possessing aircraft that may be considered for Part 115 operations. A list of participants has been collated using various advertising media related to aviation and tourism activities – including periodical publications, brochures and internet searches. The expected number of participants is expected to be greater than 30.

Instrumentation

The survey consists of
- A *Questionnaire* to individual operators (management)
- A compliance *Checklist* aimed at operator's procedural standards and practices in order to ascertain their present levels of compliance

The *Questionnaire* provides parameters for understanding the opinions of operators so as to develop themes and to identify any additional issues that may emerge. Current themes are isolated into the following key elements.
- Acceptance of the new Rule standard
- The perceived role of 149 organisations
- The provision of safety in current practices
- Resourcing for compliance with best practice

The *Checklist* provides a template that relates directly to the current NPRM and to generic SMS requirements allowing the analysis of the compliance levels presently acheived. The template presents seventy five individual elements to which the operators currently do or do not comply. The level of adherence, by operators, to these elements effectively provides a measure of a compliance gap. Adherence levels are considered in relation to whether compliance is enabled by formal stipulation, or by local informal practice, or externally sourced input to guage whether an operational process would

possess sufficient validity if properly formalised. This is an indication that an element may count towards the achievement of a compliance element – thereby reducing the compliance gap.

Procedure

The survey is being conducted by telephone interview and personal visitation to operators over April and May 2011. The resulting assessment employs information gained during the interviews and an in-depth analysis in relationship to the literature review to isolate and quantify the impact of expected and novel issues upon regulatory deployment.

Collation of the results is expected to provide nominal and ordinal data for the whole adventure aviation industry and for each activity sector. The representation of the data will include a graphical portrayal of statistical information, acceptance levels, compliance levels and stated assumptions of safety levels according to category, as well as a cross-sectional sample of opinion statements.

The expected data measurement will apply standard statistical processes including appropriate tests for statistical fit.

Results

Preliminary results will be presented at the conference. The outcomes of the research hope to ascertain the process by which the new standards provided by the Rule can be facilitated, and to identify any obstacles and possible solutions. The findings hope to establish a "compliance gap" for the various activity sectors and sub-groups. It is also intended to measure the required level of input by operators and the level and type of support needed to achieve compliance for all intending operators.

Contribution to the state-of-the-art of adventure aviation

The nature of the research applies to the application of any formal regulation on previously uncontrolled activities of a diverse nature. It is particularly relevant to all sectors of adventure tourism. It is expected the research will provide enhanced understanding of the problems of applying the new legislation and so will be of interest to policy-makers and industry participants.

AVIATION PSYCHOLOGY

Sleep pattern disruption of flight attendants operating on the Asia – Pacific route

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Abstract. *Jet lag is a common issue with flight attendants in international flights, as they have to cross several time zones back and forth, while their sleep patterns get disrupted by the legally required rest times between flights, which are normally carried out at different locations. This research aimed to investigate the sleep quality of a sample of flight attendants operating between New Zealand and Asia. Twenty flight attendants were surveyed in this research. The research found that flight attendants typically took a nap immediately after arriving into New Zealand, reporting a sound sleep time of about 6 hours. After the nap, however, they had problems falling sleep in subsequent nights. After their first nap, some flight attendants try to adapt to local light conditions, while others prefer to keep the sleep patterns they had back home. Both groups report different trends of sleep quality.*

Introduction

Nowadays, people can travel across time zones to their destinations in a matter of hours, although their body clock can take days, or even weeks, to become attuned to the destination time zone (Gander, 2003). As aviation professionals, flight attendants are among those who travel across time zones very frequently. Many studies have indicated that flight attendants usually get deep, calm, and good quality sleep during the first layover sleep after a flight, mainly due to fatigue, and prolonged and extended wakefulness during their work shift. On the second and third nights of a layover, however, they usually appear to have disturbed sleep patterns and poor sleep quality, as this is the time when jet lag shows unhindered by fatigue and extended wakefulness (Samel and Wegmann in Jensen, 1989; Stone, 2002; Grajewski et al., 2003).

A number of studies have demonstrated that the recovery rate of sleep disturbance experienced by travellers and flight attendants depends largely on two factors; the number of time zones that are crossed, and the direction of the flight (Zammit, 2000; Jensen, 1989). Obviously, the first factor makes sense and is easily understood, because the more time zones crossed, the larger the shift in the circadian clock that has to be made, and greater the effort required for circadian rhythm alignment (Gander, 2003). Why, however, does such a difference exist in the direction of the flights after time zone transition? Almost all of the laboratory experiments' (e.g., EEG tests, sleep latency tests, etc.) results using different subjects and difference variables lead to one conclusion; that the rate of adaptation to an eastward time zone shift (when the new time is ahead of the old time) is relatively slower than that for a time zone transition after a westward journey (Minors and Waterhouse, 1981; Jensen, 1989; Gander, 2003; Nicholson, 2006). Graeber (1986) further suggested that travellers adjust at an average rate of 1.5 hours per day following westward flights, and at an average rate of 1 hour on per day following eastward flights. For example, on average, it will take an individual

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only 2 days to adjust to a new time zone after 3 westward time zone transitions, whereas 3 days may be required after the return journey. Stone (2002) also found that cabin crew layover sleep after a westward time zone transition appears to be of good quality in the first part of the night and disturbed in the second part of the night; however, after an eastward time zone transition, cabin crew usually find difficulty in getting to sleep at the normal local sleep time, but appear to have improved sleep quality after they fall asleep.

Most research regarding sleep and wakefulness patterns of flight attendants travelling across several time zones have been conducted by researchers in Western countries, with few sleep studies specifically focusing on Asian flight attendants. Therefore, the purpose of this study is to analyse Asian flight attendants' sleep behaviours after travelling across several time zones.

Methodology

For our research sample, we search for an Asian airline whose operations were between an Asian country and New Zealand, and settled for one whose cabin crew would be working on a time zone difference between both countries were of four hours.

The sleep and wakefulness questionnaire survey was divided into five sections: General information; Sleep at home; Sleeping in aircraft bunk; Layover Sleeping at hotel; and Post-flight information. The answer included both quantitative and qualitative data. A 5-point scale, from 1 (very bad) to 5 (very well) was adopted to measure the average sleep quality. The Layover sleeping in hotel and Post-flight information sections were the main part of the survey. In those two sections, crewmembers were asked to fill out sleep diaries during their layover in the hotel and to continue recording sleep quality and quantity on the day they arrived at their home base. For each separate sleep a participant had during recovery days, their sleep quality was evaluated on several aspects: time taken to fall asleep, wake up time, and number of awakenings, as well as some self-rated questions including difficulty falling asleep, difficulty arising, how deep the sleep was, and how rested the participant felt.

The subjects were asked to fill in the survey and the sleep diary throughout their recovery days, both in New Zealand and during the first day after they arrived at their home base.

Our sample thus consisted of 20 cabin crew members: 13 female flight attendants around 30 years old (age ranged between 26 and 45) with average flight experience of 60 months (ranging between 8 and 240 months). And 7 male flight attendants around 28 years old (age ranged between 25 and 39), with an average flight experience of 55 months (ranging between 8 and 144 months). These sample of flight attendants averaged 71 hours a month flying on this Asia-Pacific route.

Results

The average sleep and wake pattern (both at home and in New Zealand) for the 20 participants showed that they went to bed at home approximately at 00:48 AM (Asian time), and woke up at around 10:13 AM (Asian time). The average total sleep duration at home was 10.03 hours.

Subjects also reported that it usually took them 16 minutes to fall asleep (mean = 15.8) and that they usually awakened 1 or 2 times during the night. The causes of these awakenings were grouped into 4 categories, with the two most frequently reported causes being physiological needs and noise from outside. Only 4 participants out of the 20 (20%) reported that they suffered regular sleep problems at home. However, overall, they described the quality of their sleep at home as being 'rather good'.

The outbound flight from Asia (eastward) was characterised by an extended period of wakefulness (17 hours). Sleepiness was elevated during the flight and most participants (18 out of 20) took naps onboard, although the mean length of these naps was only 1.4 hours in a 3 hour bunk rest.

	Home	1st Layover Sleep	Layover Night Sleep (Day 1)	Layover Night Sleep (Day 2)	Layover Night Sleep (Day 3)	Day Sleep (Post Flight)	Night Sleep (Post Flight)
Overall Sleep Quality (1-5)	4. 15	4. 35	3. 45	3. 25	3. 55	4. 5	4
Average Sleep Duration (hours)	10. 03	6. 03	9. 3	8. 82	9. 2	5. 02	8. 06
Average Bedtime	00:48 am	9:36am	4. 22am	4. 36am	4. 02am	10. 06am	1. 46am
Average Waking Time	10:18 am	4. 28pm	1. 46pm	1. 08pm	1. 01pm	3. 23pm	9. 52am
Mean Awakening Time	1. 3	. 65	1. 75	1. 75	1. 55	0. 25	1. 05
Time Required to Fall Asleep (mins)	16	13	88	112	108	15	33
Difficulty Falling Asleep	1. 5	1. 3	3. 4	3. 7	3. 55	1	2. 35

Figure 1: Sleep quality summary

The results also showed that all participants (100%) took an immediate nap, or sleep, of 6 hours on average (ranging from 3 to 8) after arriving at the hotel in New Zealand, after crossing 5 time zones. In fact, the participants reported that they slept extremely well during their first layover day sleep at the hotel. Several sleep parameters used in this research, such as sleep latency time, awakening frequency, and self-rated overall sleep quality indicate that the first layover day sleep was a very calm, deep sleep and was very difficult to be awakened from. As noticed, the overall sleep quality of the first hotel day sleep was even rated higher than subjects' overall sleep quality at home.

Nevertheless, participants started to have sleep and rest pattern disturbance after their first layover sleep. In regards to the effects on sleep and wakefulness patterns of the flight direction, it was found that most participants found it very difficult to fall asleep at the local time during layover nights in Auckland (eastward time zone transition), which can be identified from their ratings on the term *difficulty falling into sleep*.

Five participants chose to adapt to the local time zone and had, on average, a 3 hours shorter sleep on the arrival day into New Zealand, than the average sleep length of the other participants. Nevertheless, these participants appeared to not feel refreshed when they awakened from this day nap, and most of them reported that the use of an alarm clock to awaken was necessary. The adapted group scored an average of 3.8 in terms of having difficulty arising (1 = least difficult arising, 5 = most difficult arising), whereas the non-adapting group only scored 2.8 in this regard. For the three main night layover sleeps, the adapted group went to bed at an average time of 0:04 AM (NZ time), which was only 40 minutes later than their usual bedtime at home, and woke at 9:26 AM, which was close to their usual waking time (9:35 AM) at home.

The adapted group reported average sleep duration of 9.1 hours for the 3 main night hotel sleeps, compared with 10 hours at home, and relatively lower average awakening times of less than 1 time during their main layover sleeps were reported. It was also noticed that 90% of the adapted participants (5 out of 6) were more likely to be categorised as morning preference persons than as evening preference persons, because they reported earlier wake-up times (before or at 10:00 AM) at home. No obvious difference on overall sleep quality between the adapted group and the population mean were observed, except in the case of the first layover night sleep. For the second and third layover night sleeps, it was observed that the adapted group only scored slightly better than the population mean on overall sleep quality. It was also found, however, that the adapted participants felt that it was much less difficult to fall asleep through the layover nights, and they spent a significantly shorter average time falling to sleep through all three layover nights compared with the population mean.

After the homeward flight back to Asia (westward time zone transition), most participants reported improved overall sleep quality (mean = 4) during their first night sleep at home, and less time was also reported to fall asleep (33 minutes). It was also found that the average bedtime of participants was delayed 2 hours, from 10:40 PM (usual bedtime at home), to 00:35 AM (Asian time) for the first night sleep on returning home.

Discussion

The results of the present study confirm past research findings, which suggested that rapid time zone transitions after trans-meridian flights would cause jet lag and sleep disorders (Lafontaine et al., 1967; Gander, 2003). In this study, the results indicate that participants had relatively better sleep quality for their first layover sleep after arriving in New Zealand, with their sleep and rest patterns then disturbed in subsequent layover nights.

The results also showed that all participants (100%) took an immediate nap, or sleep, of 6 hours on average after arriving at the hotel in New Zealand, and reported a good sleep. As Gander (2003) suggested, sleep deprivation, as well as cumulative wakefulness, could be two major causes of this deep sleep. It was still more than 12 hours before local night-time when participants arrived at the hotel, so this was obviously too long a time to stay awake when they were already feeling tired. In addition, this extremely high sleep quality and fast sleep onset also reflected the need

for participants to sleep at a time equivalent to a late bedtime in their home time zone (Gander et al., 1991).

Moreover, the study clearly demonstrate that participants who chose to expose themselves to daytime light and local social cues had different sleep and wakefulness patterns from those participants who did not. Obviously, those participants who chose to adapt to local time appeared to have a similar sleep and rest pattern to their sleep and rest pattern at home, which was also closer to local time cues.

Limitations and conclusion

Obviously, the present study contains several research limitations. First of all, a questionnaire/survey study has the limitation that the data gathered from participants are subjective, which means that questions are answered from the subject's perception, memory, and interpretation of the question, with individuals possibly making inaccurate estimates of their sleep durations, awakenings, sleep latency times, and other related parameters. In other cases, some quantitative data may be interpreted differently by different individuals. For example, in questions such as *Rate your overall sleep quality for the first layover sleep in 1-5*, a rating could mean something completely different to each individual. Therefore, the subjective nature of survey data limits the generalizability of these results. To obtain more accurate data for future flight attendant sleep studies, the use of some scientific evaluation methods is suggested, such as EEGs, body temperature tests, eye movement observations, and wrist activity monitoring, together with a sleep log, or a questionnaire.

Another major limitation of this study was that the data were statistically limited by the small sample size. The whole population of this study was only 20 participants, and the targeted groups for hypothesis 3 (participants who chose to adapt to local time) had even smaller sample sizes of 5. Moreover, the results gathered form this study have lower generalizability to other flight attendants and research, as this study examined a unique case in which the participants are not required to fly to different international destinations, but only fly on a particular Asia–Pacific route. Flying on only one route means that the participants may have developed more familiarity with their layover than in many other cases.

Last but not least, the *directional theory* was not extensively discussed in this study. This was because the sleep record was only collected for one day after the westward flight back to Asia, and the insufficient number of data has limited the study to an in-depth exploration of how flight direction can affect flight attendants' sleep and wakefulness patterns after a transmeridian flight.

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Two pilots may be safer than one: The effect of group discussion on perceived invulnerability.

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Abstract

Although most general aviation (GA) pilots have received training in aviation decision making, one of the most common causes of GA accidents remains a pilot's decision to press-on with a flight, when the safe decision was to turn back or divert (Federal Aviation Authority, 2002). Presumably, pilots press-on because they assume it is safe to do so, rather than because they are foolhardy. One reason pilots press-on may be because they underestimate the inherent risks. Indeed, research into the area of perceived invulnerability (PI) suggests that many pilots perceive themselves to be invulnerable to negative outcomes and that this predicts the kinds of behaviour likely to increase the chance of accident or incident (Isenberg, 1986).

For more than 40 years, psychologists have been aware that decisions made by groups of people tend to polarise the views of individuals (O'Hare & Smitheram, 1995). Thus, if individuals make decisions that are risky, the decisions made in groups will tend to be more risky than those made by individuals. In aviation, this has potentially serious implications for flights where there are two pilots rather than one, because if individual pilots' are susceptible to PI, then when there are two pilots PI may increase.

Data collected earlier (Lee & Gilbey, 2010), which in a preliminary analysis found no effect of group polarisation on PI, was reanalysed to investigate whether an effect of group polarisation would be observed when both members of a pair of pilots exhibit PI. (Previously, all pilots had been included, regardless of whether they exhibited PI.)

The sample were seventy-eight GA pilots, recruited from seven different flight training organisations in the North Island of New Zealand (14 female, 64 male; ages 18 to 59 years ($M = 25.94$, $SD = 7.86$) flight experience ranged from 30 minutes to 5,000 hours ($Mean = 662.38$ hours, $SD = 895.13$ hours). A within-subjects design was used, in which participants completed two equivalent measures of PI; once alone, and once in pairs, following discussion.

Significant evidence of PI was found for all pilots when measured alone, $t(77) = 8.54$, $p < 0.001$ and also when measured in pairs, following discussion, $t(77) = 8.92$, $p < 0.001$. Next, unlike in our previous analysis (Lee & Gilbey, 2010), the nine pairs of participants in which one pilot did not demonstrate PI were excluded from all further analyses. (In hindsight, it was considered illogical to expect PI to be polarised following group discussion if it was not evident in individuals at the outset.) Remaining participants were allocated into two groups based upon a median split of their PI scores when measured alone (>5.8 = high PI and ≤5.8 = low PI). A 2x2 ANOVA indicated a main effect of group polarisation on PI, $F(1, 58) = 5.24$, $p = .026$ ($M_{alone} = 6.24$, $SD = 1.03$; $M_{group} = 6.01$, $SD = .96$) and an interaction between manipulation (alone vs. group) and PI score in the control condition (low vs. high) $F(1, 58) = 7.42$, $p = .009$. Contrary to predictions, pilots with the higher levels of PI when alone showed a reduction in PI when measured in groups.

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The implications of the current study, suggest that perceived invulnerability in GA may be less of a problem when two (or more) pilots fly together, than when they fly alone. Future research could thus investigate accident reports to investigate whether lone pilots are more likely than two pilots to be involved in accidents or incidents where PI was a contributing factor. The findings of this study are reassuring regarding commercial flight operations, where normally there will be two pilots.

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A convenient regression formula for predicting Skytrax's Official World Airport Star ratings

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Abstract. *Skytrax audits and ranks airports internationally in its yearly 'Official World Airport Star Ranking'. Unfortunately, its activity is severely restricted, at most covering just 3% of those airports listed by Skytrax as open to review by passengers in its website in 2010. This research article explored the possibility of using a readily available variable as predictor, as an alternative way of ranking the remaining 97% of airports in a simpler and more straightforward manner. The regression formula retained correlated highly with the criterion variable, accounting for 45% of its variance, thus supporting the viability of using customer reviews as a possible way of predicting ranking scores for airport not officially audited by Skytrax.*

Introduction

Skytrax is a consultancy firm based in London (UK), which does research and advisory consultancy mostly with the aviation sector (Skytrax, 2011a). It is probably better known for its yearly airline and airport ratings, and customer-choice-based 'World Airline Awards' and 'World Airport Awards' (Wikipedia, 2011). The former rating ranks airlines and airports according to quality, after auditing done by Skytrax itself (2011b). The second recognises the best airlines and airports as chosen after an international passenger survey (Skytrax, 2011c).

Skytrax claims to be the world largest airport review site, with over 700 airports [reviewed or open for review] and *"customer airport reviews for almost every destination you can think of!"* (Skytrax, 2011a). Yet, only 703 airports were listed as opened for customer review in 2010 (or about 0.05% of airports and airfields in the world, as per the CIA, 2010), only 135 of these airports had been in the "star ranking programme" (or 3% of the airports opened for review), and only up to 21 of these airports had been audited and obtained a ranking in 2010 (or 16% of the 135 airports in the rating programme) (Pérezgonzález & Gilbey, 2011).

However, the ratings and awards, whatever their limited coverage, give useful information about the quality of an airport, especially for those passengers in transfer or transit, which are probably the ones in the best position to notice it. A small proportion of passengers may indeed opt for a different travel itinerary according to the airport where they must stop for a number of hours (e.g., Hong-Kong, Singapore, Malaysia, Los Angeles or Dubai).

As it is the passenger who ultimately decides which way to go and where to stop and, thus, ascertains the perceived quality of an airport, we conducted a research to estimate a regression formula which allowed predicting Skytrax rating scores from customers' reviews instead of formal audits. We reported the best regression formula in Pérezgonzález & Gilbey (2011), which showed a relatively large multiple correlation with the actual ranking given by Skytrax (R = .761). This formula included all four variables which a passenger could use for rating different aspects of an airport for each

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reported experience: an overall 'Customer rating', '[Satisfaction with] Queuing', '[Satisfaction with] Cleanliness', and '[Satisfaction with] Facilities'.

The aim of this research now is to further expand that analysis and ascertain how well Skytrax ranking can be predicted from a single variable: the summary customers' reviews offered by Skytrax as 'Customer Review scoring'.

Methods

For this research, we investigated the population of 20 airports which obtained a Skytrax rating for 2010. From the airport data available at the Skytrax website, we selected two variables, readily available in the website, per airport.

The first variable acted as our criterion (or dependent) variable. This was the 'Skytrax official rating', a score on a five-anchor ordinal scale running from "1, Very poor", to "5, Excellent").

The second variable acted as our predictor (or independent) variable. This was the 'Customer review scoring', an average score on an ordinal scale running from 0 to 10 – although there is no information of how this average was obtained, it plausibly represents the average 'Customer review scoring' for all reviews, including those of previous years).

SPSS-v16 was used for all analyses. A pre-screening data analysis showed that both variables were normally distributed and suitable for analysis using a linear model. Therefore, we used parametric tests for all subsequent analysis.

Results

Results show that it is possible to retain a model for predicting Skytrax rankings from the 'Customer review scoring' supplied by Skytrax. This model is statistically significant ($F = 13.140$, $p < 0.01$), and its correlation with the criterion is relatively high ($R = .672$).

The regression model was the following:

Predicted Skytrax Ranking = .686 + (.417 * Customer review scoring)

Conclusion

Skytrax rates airports according to quality. It also aims to be the leading institution in doing so thanks to its "Official World Airport Star Ranking". Unfortunately, its activity is severely restricted, at most covering just 3% of those airports which customers have reviewed in its website. The regression model obtained in this research may help in covering a portion of the remaining 97% of airports which are not audited by Skytrax. The model presented here is potentially less useful than another predictive model presented elsewhere (see Pérezgonzález & Gilbey, 2011), as the predictor variable includes all customer reviews, not just reviews for 2010, and, therefore, it reflects less contemporary opinions. However, it is much simpler (one predictor variable instead of four) and straightforward (the score is readily available in Skytrax's website, instead of needing the compilation of a database of individual experiences and the computation of averages), and what it looses in representativeness may be gained in convenience without necessarily affecting the underlying prediction.

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Predicting Skytrax's Official World Airline Star ratings from customer reviews

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Abstract. Skytrax audits and ranks airlines internationally in its yearly 'Official World Airline Star Ranking'. Unfortunately, its activity is severely restricted, at most covering just 30% of those airlines listed as open for review by passengers in its website in 2010. This research article explored the possibility of using a readily available variable as predictor, as an alternative way of ranking the remaining 70% of airlines in a simpler and more straightforward manner. The regression formula retained correlated highly with the criterion variable, accounting for 47% of its variance, thus supporting the viability of using customer reviews as a possible way of predicting ranking scores for airlines not officially audited by Skytrax.

Introduction

Skytrax is a consultancy firm based in London (UK), which does research and advisory consultancy mostly with the aviation sector (Skytrax, 2011a). It is probably better known for its yearly airline and airport ratings, and customer-choice-based 'World Airline Awards' and 'World Airport Awards' (Wikipedia, 2011a). The former rating ranks airlines and airports according to quality, after auditing done by Skytrax itself (2010). The second recognises the best airlines and airports as chosen by passengers by means of an international survey (Skytrax, 2011b).

Skytrax (2010) claims to be the world's largest airline review site, with over 670 airlines [reviewed or open for review] and *"millions of airline and airport reviews online"*. Yet, only 641 airlines were listed as opened for customer review in 2010 (or about 16% of passenger airlines in the world, as per Wikipedia, 2011b), only 244 of these airlines had been in the "star ranking programme" (or 30% of the airlines opened for review), and only 192 of these airlines had been audited and obtained a ranking in 2010 (or 79% of the 244 airlines in the star ranking programme) (Pérezgonzález & Gilbey, 2011a).

In previous research we have reported regression models for predicting Skytrax ratings from customers' reviews, both for airports (Pérezgonzález & Gilbey, 2011b) and for airlines (Pérezgonzález & Gilbey, 2011a). However, those models tend to include several variables, require the compilation of a database of individual reviews, and require the calculation of subsequent averages for further analysis. For example, the best prediction model for Skytrax airlines ratings included three variables: 'Customer rating', 'Recommended [as valuable airline]', and 'Value for money [evaluation]', resulting in a relatively high multiple correlation index between predictors and criterion (R = .689).

Still so, the compilation of those variables is cumbersome and time consuming. In a recent article, however (see Pérezgonzález & Gilbey, 2011c), we reported a regression model for predicting Skytrax ratings for airports from a single, readily available, averaged variable provided by Skytrax in its website. The resulting model was slightly

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less powerful than the one reported in Pérezgonzález and Gilbey (2011b), yet simpler and more straightforward to use.

The aim of this research now is to ascertain how well Skytrax airline rankings can be predicted from a similar single variable: the average customers' reviews offered by Skytrax as 'Customer review scoring'.

Methods

For this research, we investigated the population of 115 airlines which obtained a Skytrax rating for 2010 and had a minimum of 10 customer reviews during the year. From the data available at Skytrax's website, we selected two variables, readily available in the website, per airline.

The first variable acted as our criterion (or dependent) variable. This was the 'Skytrax official ranking', a score on a five-anchor ordinal scale running from "1, Very poor", to "5, Excellent").

The second variable acted as our predictor (or independent) variable. This was the 'Customer review scoring', an average score on an ordinal scale running from 0 to 10 – although there is no information of how this average was obtained, it plausibly represents the average 'Customer review scoring' for all reviews, including those of previous years).

SPSS-v16 was used for all analyses. A pre-screening data analysis showed that both variables were normally distributed and suitable for analysis using a linear model. Therefore, we used parametric tests for all subsequent analysis.

Results

Results show that it is possible to retain a model for predicting Skytrax airline rankings from the 'Customer review scoring' supplied by Skytrax. This model is statistically significant ($F = 87.302$, $p < 0.01$), and its correlation with the criterion is relatively high ($R = .688$).

The regression model was the following:

$$\text{Predicted Skytrax Ranking} = 1.675 + (.291 * \text{Customer review scoring})$$

Conclusion

Skytrax rates airlines according to quality. It also aims to be the leading institution in doing so thanks to its "Official World Airline Star Ranking". Unfortunately, its activity is severely restricted, at most covering just 30% of those airlines which customers have reviewed in its website. The regression model obtained in this research may help in covering a portion of the remaining 70% of airlines which are not audited by Skytrax. The model presented here is potentially less useful than another predictive model presented elsewhere (see Pérezgonzález & Gilbey, 2011a), as the predictor variable includes all customer reviews, not just reviews for 2010, and, therefore, it reflects less contemporary opinions. However, it is much simpler (one predictor variable instead of three) and straightforward (the score is readily available in Skytrax's website, instead of needing the compilation of a database of individual scores and the computation of averages), and what it looses in representativeness is gained in convenience without necessarily affecting the underlying prediction.

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COMMERCIAL ASPECTS

OF AVIATION

Canada / UAE Aeropolitical Relations – Implications for New Zealand

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Abstract

The paper presents policy comparisons between recent aeropolitical disputes involving Canada and the United Arab Emirates and New Zealand's policy options with respect to managing interest from large Middle Eastern airlines. The basis of the Canada–UAE dispute was the ability, in the factual, of Middle Eastern sixth-freedom carriers to transport passengers from North America to Europe via their home base and what effect this would have on uplift managed by Canadian carriers between Canada and Europe.

There exist parallel issues for New Zealand that can be identified in the Canada–UAE aeropolitical dispute.

Two are of prime importance:

1. How is capacity for large Sixth Freedom carriers with "thin market" origins measured? Some existing air service arrangements — notably New Zealand–United Arab Emirates — utilise phrasing such as "reasonable load factor" and "capacity adequate for the current and reasonably anticipated requirements of passengers". Should associated restrictions or entitlements be reviewed to address differences between origin-destination (end-to-end) traffic or full uplift and discharge? What are the counter-factual and factual implications with respect to regional airlift from New Zealand's key markets from such a review?

2. Where do Australia–New Zealand routes factor into decisions by Middle Eastern airlines in providing services to New Zealand and how might this change in factual / counter-factual scenarios of increased access, alliances and shifts in external operating conditions?

The Canada–UAE aeropolitical dispute provides a lens through which at least two policy options for New Zealand's management of interest from large Sixth Freedom airlines can be assessed:

1. A broad approach which privileges, in principle, national interests involving designated carriers against additional capacity requests from sixth freedom carriers.

2. A case-by-case, situational approach, which may allow responses where national economic interests require flexible and, at times, variable policy positions and instruments to be developed.

The paper argues that any national policy statement byNew Zealand will need to review Australian policy as well as embed New Zealand decisions within a framework that captures both wider trade-related goals and accessibility.

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Forecasting airport passenger traffic: the case of Hong Kong International Airport

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Abstract: Hong Kong International Airport is one of the main gateways to Mainland China and the major aviation hub in Asia. An accurate airport traffic demand forecast allows for short and long-term planning and decision making regarding airport facilities and flight networks. This paper employs the Box-Jenkins Autoregressive Integrated Moving Average (ARIMA) methodology to build and estimate the univariate seasonal ARIMA model and the ARIMX model with explanatory variables for forecasting airport passenger traffic for Hong Kong, and projecting its future growth trend from 2011to 2015. Both fitted models are found to have the lower Mean Absolute Percentage Error (MAPE) figures, and then the models are used to obtain ex-post forecasts with accurate forecasting results. More importantly, both ARIMA models predict a growth in future airport passenger traffic at Hong Kong.

Introduction

After the 1997 changeover in Hong Kong from Britain sovereignty to Mainland China control, and 14 years after the opening of Hong Kong International Airport (HKIA), airport passenger traffic has been in steady growth generally. However, several authors (Hobson & Ko, 1994; Seabrooke, Hui, La & Wong, 2003; Zhang, 2003) have predicted a decline in air passenger and cargo throughput for Hong Kong International Airport and have raised concerns regarding its dominant role as an international hub and a gateway to Mainland China. Furthermore, Zhang, Hui, Leung, Cheung and Hui (2004, p.95) stated that "*neither the [Hong Kong's] gateway role nor the hub role should be taken for granted, and it will be risky to think that the hub role may be maintained forever and ... high growth rates will persist for a long time*".

An accurate and reliable airport passenger demand forecasting is an integral component for short-term and long-term planning and decision making regarding airport infrastructure development and flight networks.

However, Hong Kong's future airport passenger demand is somewhat less well researched, although tourist arrival forecasting has been recently studied (Cho, 2003), and thereby indicates a gap for this paper to fill. In addition, to my best knowledge, this paper is the first empirical study on airport passenger demand for HKIA using time-series methods. The objective of this paper is thus to build time-series forecasting models to accurately predict airport passenger traffic at Hong Kong, and making a projection regarding its growth in future air passenger traffic from 2011 to 2015.

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Methods

Sample

Discreet months between January 2001 and February 2011 comprise the 'subjects' of the research. This amounts to 122 observations (equal to 12 months times 10 years, plus two additional months). The forecasting models are estimated and built using the data from January 2001 to November 2010, and the remaining data from December 2010 to February 2011 are retained to assess the ex-post forecasting performance of the models.

The variables of interest for our research are several, such as "monthly airport passenger traffic data for HKIA" (obtained from the Hong Kong Airport Authority), "GDP per capita", "monthly visitors by air", "connecting traffic", etc. Of these variables, the "monthly airport passenger traffic data for HKIA" (obtained from the Hong Kong Airport Authority) will act as our main dependent variable, whose future demand we want to project into the future. The remaining variables, collected from the Census and Statistics Department of Hong Kong, the International Monetary Fund and the Hong Kong Tourism Board, will act as our main explanatory variables.

Statistical analyses

This paper employs the Box-Jenkins univariate seasonal ARIMA model and ARIMAX model for predicting future trends in airport passenger traffic for HKIA from March 2011 to December 2015 (Uddin, McCullough & Crawford, 1985; Cheung, 1991); Kawad & Prevedouros, 1995; Prevedouros, 1997; Chen & Chen, 2003; Andreoni & Postorino, 2006; Jia, Sun, Wan & Ma, 2007; Payne & Taylor, 2007; . Lee, 2009; Abdelghany & Guzhva, 2010; Samagaio & Wolters, 2010). The Box-Jenkins ARIMA methodology (1976) can be described as follows:

Theoretically, Box-Jenkins ARIMA models are built empirically from the observed time series relying on three underlying process components: Autoregressive (AR), Integrated (I) and Moving Average (MA) (Box & Jenkins, 1976; Pankratz, 1983: Box, Jenkins & Reinsel, 2008; Gujarati & Porter, 2009). In practice, the Box-Jenkins process uses a pth-order autoregressive process (p), a qth-order moving average process (q), and a level of differencing (d) to build the most appropriate fitted model for forecasting time series.

The autoregressive process implies that an observed event at a specific time period depends on its value in the previous time period and error term. The moving average process means that an observed event at a specific time is dependent on the previous values of its error term. The integrated process indicates the level of differencing required to make time series stationary. Most importantly, the ARIMA models can only be used when the time series is stationary.

The general Box-Jenkins ARIMA model is considered as the non-seasonal ARIMA (p,d,q) model. However, the seasonality is very common with air passenger traffic or tourist arrival time series. Therefore the seasonal ARIMA $(P,D,Q)_s$ model is developed taking into account seasonal patterns in the time series, such as quarterly, semi-annual or annually. Combining the non-seasonal ARIMA (p,d,q) model and the seasonal ARIMA $(P,D,Q)_s$ model, and then the seasonal ARIMA can be expressed as follows: SARIMA $(p,d,q) \times (P,D,Q)_s$[4]

The Box-Jenkins ARIMA model thus includes four specification techniques: identification, estimation, diagnostic checking, and forecasting (Box & Jenkins, 1976).

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[4] p and P denotes non-seasonal and seasonal autoregressive process; q and Q denotes non-seasonal and seasonal moving average process; d and D denotes level of differencing required to make time series being stationary for non-seasonal and seasonal process.

Results

Figure 1 displays the monthly log-airport passenger traffic passing through Hong Kong between January 2001 and February 2011.[5] Based on graphical analysis, the time series exhibits an upward trend along with the possibility of seasonal patterns. More importantly, the SARS outbreak caused declines in airport passenger traffic between late 2002 and mid-2003. In the seasonality plot, we can observe a peak every July and August, indicating high travel periods during the summer holidays, followed by a drop in September. Another peak occurs every December and March.

Figure 1: Log-airport passenger traffic (left-side) and

the seasonality plot (right-side)
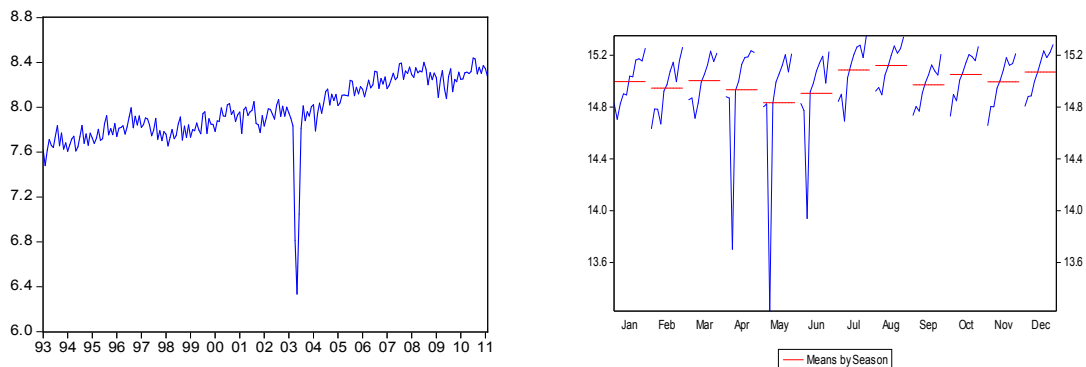
Before estimating log-airport passenger traffic time series, we checked whether the time series data was stationary. The Augmented Dickey-Fuller test was significant (t=-4.376, p < .01), indicative of the time series being stationary. Thus, further differencing process were not required.

Moreover, the correlograms of Autocorrelation (ACF) and Partial Autocorrelation (PACF) indicate that the time series have some seasonal, autoregressive and moving average processes. This suggests the use of the SARIMA model. After extensive trial-and-error, using the lowest test results of Akaike Information Criterion (1974) and Schwarz Information Criteria (1978), we decided that the best-fit model with best forecasting performance for predicting airport passenger traffic for Hong Kong was the univariate seasonal ARIMA $(1,0,1) \times (1,0,1)_{12}$ model.

Furthermore, we also found that the residuals fell within the 95% of confidence level in the residual correlograms of ACF and PACF,[6] and also there are "*white noise*" process.[7] In addition, the Ljung-Box *Q*-statistics (1978) suggests one fails to reject the null hypothesis of no autocorrelation. After performing the Ordinary Least Squares (OLS) estimation procedure, Table 1 shows all of the AR and MA terms are statistically significant at above the 99% confidence level, as well as the fitted univariate seasonal

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[5] The variance appears significantly change much over time in the original time series of monthly airport passenger traffic, and then the logarithm transformation is chosen stabilise the variance.

[6] For the sake of brevity, the correlograms of residuals of univariate seasonal ARIMA model are not reported in this paper. The correlograms would be available upon request.

[7] "*White noise*" process of residuals means that they are independent and identically distributed with zero mean and variance σ^2 $(\varepsilon_t \sim iid\ N(0, \sigma^2)$.

ARIMA model has the overall predictable power with an adjusted-R^2 of 0.850 and it is quite accurate with a small MAPE figure (0.633%) (Lewis, 1982).

**Table 1: Estimated results of the univariate seasonal ARIMA model**

Dependent variable = log-airport passenger numbers

Explanatory variables	Coefficient	*t*-statistics
Constant	15.693***	17.299
Trend	-0.001	-0.287
AR(1)	0.574***	7.090
SAR(12)	0.858***	9.366
MA(1)	0.650***	5.382
SMA(12)	-0.944***	-34.152
R^2	0.858	
Adjusted-R^2	0.850	
MAPE (%)	0.633	

Remarks:
1) Method: Ordinary Least Squares (OLS)
2) Sample (adjusted): 2002M02−2010M11
3) Included observations: 106 after adjustments
4) *** indicates the variable is significant in either at above the 99% confidence level (two-tailed)

In addition, Figure 2 shows the comparison of residuals (the difference between the forecasted airport passenger traffic with actual values). Two main conclusions are derived from the residual patterns. First of all, the fitted values are sufficiently close to the actual values; particularly the graph captures the adverse impact of SARS outbreak upon airport passenger traffic at Hong Kong. Second, the fitted univariate seasonal ARIMA model has the ability to preserve both short and long-term memory and can be used for long-term forecast of passenger traffic for HKIA. In addition, HKIA's future passenger traffic demand is projected to grow towards 2015.

Figure 2: Actual, fitted and residuals for the univariate seasonal ARIMA model (left-side) & Monthly passenger traffic projection (right-hand)
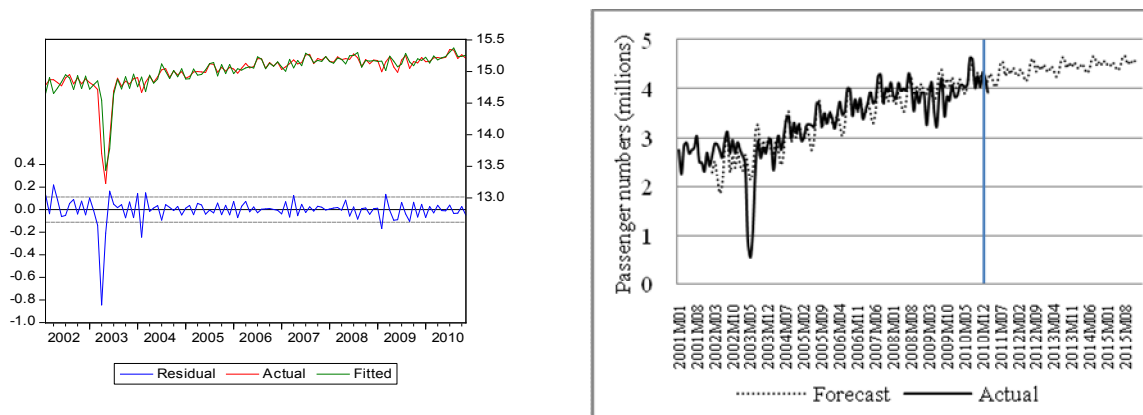
After selecting the univariate seasonal ARIMA model, this paper continues to apply the ARIMAX model (i.e., the multivariate ARIMA model). In the essence of ARIMAX

modelling, the forecasting of future airport passenger traffic demand for HKIA can further be explained by the changes in originating or local traffic, visitors by air, connecting traffic (transfer and transit passenger traffic) via the airport,[8] along with other interventions or shocks (i.e., the SARS outbreak, Cross-Strait direct flight agreement between China and Taiwan, fuel price, Individual Travel Scheme). In order to estimate the ARIMX model, future forecasted values relate to the explanatory variables and the likely impacts of interventions (shocks) need to be estimated. This paper resorts to a combination of available forecasts/estimates from the external sources and the ARIMA application. For the originating traffic, the forecasts of Hong Kong's GDP per capita obtained from the International Monetary Fund (IMF) are used as the proxy due to the direct correlation between airport demand and GDP.[9] Unfortunately, future forecasts for visitors by air and connecting traffic are more difficult to obtain due to the lack of published data, and thus their future forecasted values are predicted by employing the Box-Jenkins ARIMA methodology. After extensive trial-and-error specification, the best-fit models for log-visitors by air and log-connecting traffic are the SARIMA $(4,0,2) \times (1,0,0)_{12}$ model and the SARIMA $(2,0,2) \times (1,0,0)_{12}$ model, respectively. Both fitted SARIMA models have the MAPE figures of 1.091% and 0.841%.

Moreover, the likely effects of interventions (shocks) are captured by employing dummy variables in accordance with their permanent or temporary effects.[10] For example, fuel price is assumed to maintain at the level of more than US$80 per barrel between March 2011 and December 2015.

$$Fuel_t = \begin{cases} 1, & if \ t \geq US\$80 \ per \ barrel \ (at \ and \ after \ the \ intervention) \\ 0, & otherwise \end{cases}$$

As described above, the ARIMAX modelling is first to incorporate the selected univariate SARIMA $(1,0,1) \times (1,0,1)_{12}$ model, and then we employed the General-to-Specific (GS) approach to determine the lags of log-GDP per capita, log-visitors by air and log-connecting traffic by eliminating variables which are statistically insignificant, as well as inserting identified interventions (shocks) during the regression analysis (Henry, 1995; Song, Wong & Chon, 2003; Balli & Elsamadisy, 2010). Table 2 shows the parameters of regression coefficients and the ARIMAX model has a good fit with an adjusted-R^2 of 0.993 and the lower MAPE figure of 0.127%.

Given no further improvement can be achieved for the ARIMAX model, and also the ACF and PACF correlograms and the Ljung-Box Q-statistics (1978) confirm the "*white noise*" characteristics of residuals. From Figure 3, we found that the fitted airport passenger traffic for HKIA are more closely resemble the actual values shown, suggesting the ARIMAX model has more predictive power with additional explanatory

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[8] Hong Kong International Airport experiences more transfer or transit passenger traffic, since it plays a role of the international gateway airport to the Pearl River Delta region and Mainland China, and also the international transportation hub to Asia and Southeast Asia (O'Conner 1995; Oum & Yu, 2000; Zhang *et al.*, 2004; Mason, 2007).
[9] For checking purpose, IMF and the Census and Statistics Department of Hong Kong offered the same figures of Hong Kong's GDP per capita between 2001 and 2010.
[10] For the sake of brevity, the future forecasts for log-visitors by air and log-connecting traffic, the assumptions of future impacts of intervention (shocks) are not reported. These figures would be available upon request.

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variables than the univariate seasonal ARIMA model. Similarly, the ARIMX model also predicts a steady growth in future airport passenger traffic at Hong Kong for the period from 2011 to 2015.
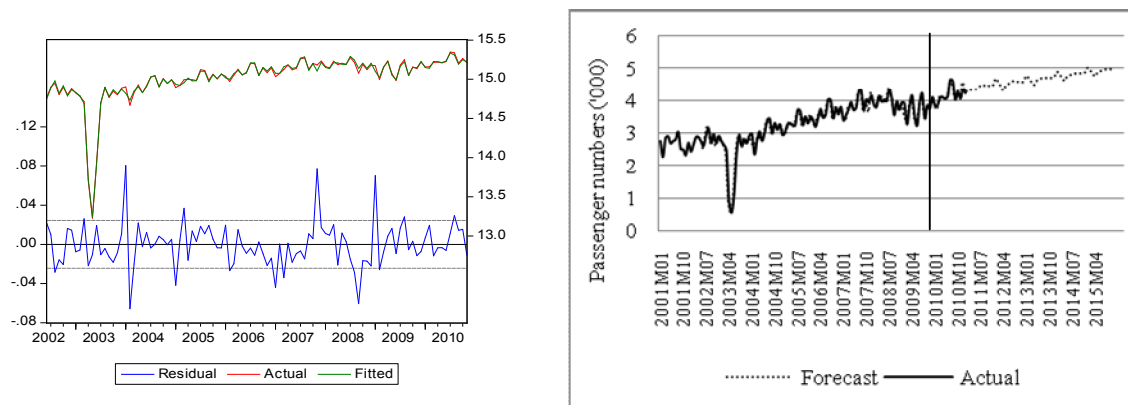
Table 2: Estimated results of the ARIMAX model

Dependent variable = log-airport passenger traffic		
Explanatory variable	**Coefficient**	***t*-statistics**
Constant	6.095***	7.995
Trend	0.002***	3.312
Log-GDP per capita	0.350*	1.891
Log-GDP per capita(-1)	-0.198	-0.628
Log-GDP per capita(-2)	-0.326*	-1.875
Log-GDP per capita(-3)	-0.371***	-2.986
Log-GDP per capita(-4)	0.404***	3.602
Log-Connecting traffic	0.237***	5.416
Log-visitors by air	0.489***	13.998
SARS	-0.027**	-2.085
Cross Strait	-0.028***	-3.674
Fuel price	0.050***	5.292
IVS	-0.013	-0.876
AR(1)	0.482***	3.062
SAR(12)	0.789***	13.037
MA(1)	-0.997***	-35.981
SMA(12)	-0.931***	-41.886
R^2	0.994	
Adjusted-R^2	0.993	
MAPE(%)	0.127	

Remarks:
1. Method: Ordinary Least Squares (OLS)
2) Sample (adjusted): 2002M06−2010M11
3) * and ** and *** indicates the variable is significant in either at above the 90%, 95% and 99% confidence level (two-tailed)
4) The lags of each explanatory variable is decided when it become statistically significant using *t*-statistics
5) AR and MA terms included are to capture autoregressive and moving average relationships in the time series

Figure 3: Actual, fitted and residuals for the ARIMAX model (left-side) & Monthly passenger traffic projection (right-hand)

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Evaluation of forecasts

It is important to check the forecast accuracy of both fitted ARIMA models by evaluating ex-post forecasts using the period of December 2010 and February 2011. After transforming log-airport passenger traffic to absolute values, Table 3 shows the forecasting performance of both fitted models by comparing their actual airport passenger traffic and forecasted values.[11] We found that the forecasted errors of univariate seasonal ARIMA model are smaller compared to those of ARIMX model. Another finding is that, for both models, the forecasted errors are very accurate within two months forecast horizon, and the forecasted errors increase remarkably when the forecast horizon gets to three month. This indicates that both models may experience larger forecasted errors for long-term forecasts.

Table 3: Forecast performance between ARIMA models

Periods	Actual	Univariate seasonal ARIMA model		ARIMAX model	
		Forecast	Forecasted errors (%)	Forecast	Forecasted errors (%)
2010M12	4,328,138	4,353,869	-0.59	4,562,261	-5.41
2011M01	4,206,217	4,220,524	-0.34	4,243,759	-0.89
2011M02	3,909,319	4,162,938	-6.49	4,317,438	-10.44

Conclusions

In summary, the best-fit Box-Jenkins univariate seasonal ARIMA model and the ARIMAX model are built for predicting airport passenger traffic for Hong Kong. The ex-post forecasts indicate that both fitted models provide accurate and reliable forecast results ranging from -0.59 to -10.44 percent. For the long-term forecasts, both models may suffer from larger forecasted errors. However, Hong Kong airport's future passenger traffic is projected to maintain a growth trend for the period of March 2011 to December 2015, and more importantly, this projection highlights the challenges for policy makers, airport authority and airline management to meet the increasing demand of airport passenger traffic at Hong Kong.

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[11] See Wooldridge (2009), the procedures for transforming forecasted log-airport passenger traffic to forecasted absolute values should take into account of the residuals presented in the time series.

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The net profitability of airline alliances using referential dollars

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Abstract. *This study revises a previous research in which we analysed the net profitability of airline alliances but did not control for the impact of inflation on such profitability. Using the same methodology, 15 international airlines as subjects and their net financial results for a period of 11 years as primary research variables, we now compared the performance of airlines before and after joining their respective alliances using referential dollars (i.e., constant dollars with 2010 as base year) instead of nominal dollars. The results showed a similar deterioration in short-term net profits after joining an alliance as the previous study did, and a similar behaviour of statistics tests. Thus, the conclusion then achieved still stand after this revision.*

Introduction

In 2010, we presented some first data on the profitability of airlines after they joined an alliance. The data covered average profitability during a 'short-term period' of 3 years and a 'medium-term period' of 5 years immediately before airlines joined their alliances. Both periods were compared against the average profitability 5 years after airlines joined an alliance. Our results showed deterioration in net profits after joining an alliance, although this trend was only significant when comparing performance for the short-term period (Pérezgonzález & Lin, 2010).

Unfortunately, in that study we made the mistake of not accounting for the impact of inflation on the reported profitability. This mistake had the potential of being important because each variable captured net profitability for the years before and after joining an alliance, not for natural years. Without accounting for inflation, computation of economic performance was being less accurate than actual performance was.

Nonetheless, we envisage that any threat was rather against the conclusions of that study. That is, the further back in time, the greater the inflation correction needed to be made, which would increase the actual differences between before and after periods. Thus, we expected that the use of referential values (Pérezgonzález, 2011) instead of nominal values may actually come up with more significant results in the direction of the previous study's conclusions.

Therefore, the primary focus of this study here was to revise our previous study (Pérezgonzález and Lin, 2010) in which we did not account for the impact of inflation on the economic variables of our research. The overall study still explored the benefits or otherwise of joining global strategic alliance groups and, more specifically, aimed to provide empirical evidence of the effects of joining an alliance on the net results of airline members in recent times.

Methodology

The methodology replicates that used in 2010 (Pérezgonzález and Lin, 2010), except that we have transformed the nominal dollar value of the economic variables in that

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study into referential dollar values (i.e., constant dollars, using 2010 as base year – Pérezgonzález, 2011).

The primary data for this research were the yearly net results per airline. We estimated that 11 consecutive years of data reporting, including the five years prior to joining an alliance, the year of joining the alliance, and the five years after joining the alliance would suffix the research purpose.

The database for this research thus consisted of 15 airlines as subjects and 11 variables as main research data. From these 11 variables we computed three averages: an average for the 5 years after airlines joined their alliance, an average for the 3 years before the airlines joined their alliance, and an average for the 5 years before the airlines joined their alliance.

Before proceeding with any data analysis, we screened the research variables to check whether they were suitable for using parametric tests or not. We found that 6 out of the initial 11 variables had significantly non-normal skewness, and 4 of these also had significantly non-normal kurtosis. As per the three average variables, two had significantly non-normal skewness, and one also had significantly non-normal kurtosis. In view of these results, we considered more appropriate to use non-parametric statistical tests for our data analyses than parametric ones. We settled for a rather lenient significance level of 0.10 in order to compensate for a larger Type II error due to our small sample size (which tends to have larger standard errors than large samples) and the use of non-parametric tests.

Results

Wilcoxon signed rank test for paired samples showed a negative significant difference between the short-term period before and after airlines joined their alliance ($Z = -2.499$, $p = 0.012$). Short-term net results after joining an alliance[12] have been significantly worse than net results before joining the alliance.

| Illustration 1. Referential and nominal net results for the overall sample		
Net results	rUSD	USD
	Mean (S.D.)	Mean (S.D.)
Medium-term, Pre 5 years	285,133 (397,029)	210,604 (287,532)
Short-term, Pre 3 years	441,133 (420,897)	323,562 (314,790)
Short-term, Post 5 years	-157,861 (816,512)	-140,666 (694,593)
*Statistical tests carried out on rUSD.		

Kruskal-Wallis H tests for several independent samples only showed a significant difference in net results after joining an alliance among airlines grouped according to geographic domicile ($\chi^2_{(df\ 2)} = 9.075$, $p = 0.01$). Further Mann-Whitney U tests for two independent samples showed that the main differences between these groups were found between American and European airlines ($U = 0.0$, $p = 0.007$), and between American and Asian airlines ($U = 0.0$, $p = 0.034$).

Illustration 2 is a graphic representation of net profit per year per airline. Indeed, the three American airlines in the sample seem to account for the most negative results after

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[12] Short-term results refer to the 3 years prior to joining an alliance and the 5 years after joining the alliance. The latter is so in order to account for performance in 2001 and 2002, i.e. after September 11th 2001. Medium-term results refer to the 5 years prior to joining the alliance but, as there are no medium-term results after joining the alliance, the 5 years after joining the alliance was used, instead.

joining an alliance. The distinctive negative results by American Airlines and United Airlines coincided with the years 2001 and 2002, while the distinctive negative results for Delta coincided with the years 2001, 2002, 2004 and 2005. When American airlines were controlled for in the sample, a Wilcoxon signed rank test for paired samples showed no significant difference in net results before and after joining an alliance.

Illustration 2. Graph of net results per airline along 11 years, distributed around the joining year
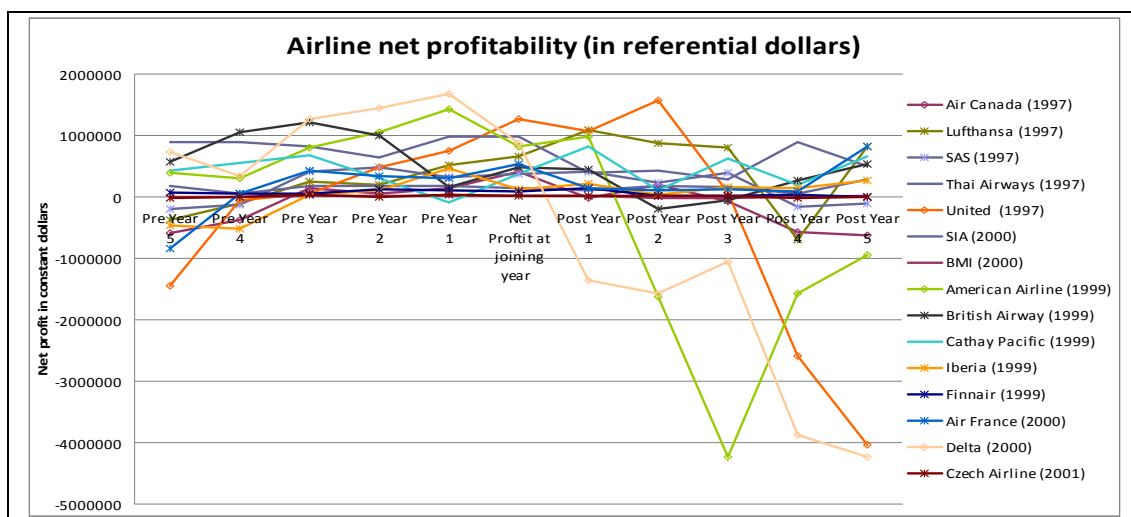
Discussion and conclusions

Our research replicated the results found in our previous study (Pérezgonzález and Lin, 2010), and the conclusions made then still stand once nominal dollars have been transformed into referential dollars (Pérezgonzález, 2011). Namely, the short-term net profit reported by airlines has not increased after joining an alliance, but rather seems to have gone in the opposite direction and has deteriorated significantly.

However, such interpretation needs to be taken with caution. Overall, it seems that American airlines are the ones which account for most of the negative performance in the sample. The events of September 11th 2001 may be there to account for the drop in performance, at least partly. Yet we do not have evidence to test the real role that September 11th played on the performance reported by airlines, nor a way to ascertain whether the same events did not affect European or Asian airlines in the same manner than they affected American airlines. In any case, it appears that pertaining to an alliance has not helped buffer the potential negative effects of these events on, at least, American airlines' performance.

This research is but a second empirical step in studying the benefits or otherwise of joining an alliance. Variables of interest for future study are those useful to continue comparing performance before and after joining an alliance, variables such as operational costs, number of passengers transported, etc. New research goals will, thus, explore the effect of alliances on those variables in the coming future.

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Comparing the net profitability of airline alliances against that of airlines not in an alliance

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Abstract. *This study compares the net return of airlines which have joined alliances against a control group of airlines which have not joined any alliance. In particular, the net financial results for a period of 11 consecutive years were extracted for 21 airlines from ICAOData. We compared the alliance and non-alliance groups in their performance before and after joining an alliance (or equivalent measure), as well as in their relative net performance. Results show a significant deterioration of net profits for the alliance group and a significant improvement for the non-alliance group. This group also differed significantly from the alliance group in having a positive relative net performance in the short-term. Thus, results suggest that not being in a strategic alliance has worked out more profitably for the 'independent' airlines than being in one has worked out for the 'allied' ones.*

Introduction

The airline industry is one of several industries that have adopted the strategic alliance model in their operations. However, few studies have analyzed whether airlines are more profitable in an alliance or out of it. The study by Oum, Park, Kim and Yu (2004) is one of few addressing the question empirically. In assessing the benefits brought by intra-alliance cooperation, they found that airlines did not gain significant performance improvements after joining the alliance. And Pérezgonzález and Lin (2010, 2011) found that airlines in strategy alliances have performed significantly worse after joining their alliances than they were doing before joining them.

However, above studies seem to have analyzed just the one group of airlines in an alliance, without having a clear external referent for assessing whether not being in an alliance would have work better for the airlines. It may always be the case that airlines not in an alliance have actually done worst than those within one.

Therefore, this study further expands Pérezgonzález and Lin's research by comparing the net performance of airline alliances against that of a group of airlines not in an alliance in the same period of time. Any results from this study are, thus, potentially more valid as the study actually has a control group of airlines not in an alliance against which to compare the economic performance of airlines in a strategic alliance.

Methodology

The main source of data for this research was the financial database compiled by ICAO (ICAOData), as presented in Pérezgonzález and Lin (2010) and used in Pérezgonzález and Lin (2011), to which we add another subsample of 6 airlines not pertaining to an alliance (at least not during the reported period).

The database for this research thus consisted of 21 airlines, and 11 initial variables representing 11 consecutive years of data reporting, including the five years prior to

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joining an alliance, the year of joining the alliance, and the five years after joining the alliance, or equivalent period of time between 1995 and 2005 for airlines not in an alliance.

From those initial variables, we computed five main research variables: the average net profitability for the 5 years after airlines joined their alliance, the average net profitability for the 5 years before airlines joined their alliance, the average net profitability for the 3 years before airlines joined their alliance, medium-term relative net performance (= average net profitability of 5 years after joining alliance - average net profitability of 5 years before joining alliance), and short-term relative net performance (= average net profitability of 5 years after joining alliance - average net profitability of 3 years before joining alliance). Equivalent values were obtained for the control group, using the year 2000 as "joining' year. All nominal values (USD, S) were also transformed into referential values (rUSD, r$) (i.e., constant values, using 2010 as base year – Pérezgonzález, 2011).

Before proceeding with the analysis of data, we screened the research variables to check whether they were suitable for using parametric tests or not. We found that most variables were significantly non-normal in skweness and kurtosis. These results thus suggested that non-parametric tests were more suitable for our intended data analysis. We used SPSS/PC+ (16.0) for data analysis, and non parametric, two-tailed tests, as our main statistics. We settled for a rather lenient significance level of 0.10 in order to compensate for a larger Type II error due to our small sample size (which tends to have larger standard errors than large samples) and the use of non-parametric tests.

Results

A Wilcoxon signed rank test for paired samples showed significant deterioration in net profitability in the short-term period before and after airlines joined their alliances ($Z = -2.499$, $p = 0.01$) but not so for the medium-term period ($Z = -1.420$, $p = 0.16$). As for the non-alliance group, longitudinal differences showed a significant improvement in net profitability in the short-term period before and after 2000 ($Z = -2.033$, $p = 0.04$) but not necessarily so for the medium-term period ($Z = -1.195$, $p = 0.23$).

We also used a Mann-Whitney test for two independent samples to explore whether the differences in relative net performance between both subsamples were also statistically significant. Results showed that both subsamples differed significantly in their short-term relative performance ($U = 18.0$, $p = 0.04$) but not so in their medium-term relative performance ($U = 30.0$, $p = 0.51$).

Illustration 1. Net results for airlines both in an alliance and not in an alliance.

	Airlines in an alliance		Airlines not in alliance
Net results	Mean (S.D.)[*]		Mean (S.D.)[*]
Medium-term, Pre 5 years	285,133 (397,029)		6,404 (65,119)
Short-term, Pre 3 years	441,133 (420,897)		-8,052 (82,001)
Short-term, Post 5 years	-157,861 (816,512)		8,572 (35,797)
Medium-term relative performance	-442,994 (1,067,800)		1,303 (74,015)
Short-term relative performance	-598,994 (1,151,040)		16,624 (72,493)

*Values in thousands of referential USD.

Discussion and conclusions

This research further expands the results of another (see Pérezgonzález and Lin, 2011) with the particularity that we have now compared the alliances' net performance against the net performance of a control group of airlines not in an alliance during, approximately, the same period of time.

The lack of significant overall impact of alliance membership on airlines' profitability over the years reported by Oum, Park, Kim and Yu (2004), and our own suggestions that the impact on profitability may have been significantly negative, at least, in the recent short-term (Pérezgonzález and Lin, 2010, 2011), is now further supported by the results here presented. Indeed, our results support the interpretation that the group of airlines not in an alliance have been significantly better off in the short term than airlines which were in an alliance. In fact, airlines not in an alliance seem to have made a profit in that time, while airlines in alliances have drawn a loss.

No doubt, these results are but a glimpse of airline alliances' economics. After all, we only found adequate data for a rather small sample of airlines, and the impact of potential mediator and modulating variables have not been controlled for. For example, it may be that the events of September 11th 2001 may be there to account for the drop in performance in alliance groups, as suggested elsewhere (Pérezgonzález and Lin, 2010, 2011), but we do not yet have evidence to test the real role that September 11th played on such performance nor a way to ascertain why airlines not in an alliance would not have been equally affected.

It is also possible that smaller airlines tend not to be in alliances and, thus, are more flexible to adapt to changing circumstances, although this would certainly contradict one of the reasons to pertain to an alliance in the first place.

All in all, we do not have ready answers whether pertaining to an alliance is beneficial or not, and why that should be so. We only have some data that illustrate that, at least at some time in the recent past, a group of airlines not in an alliance seems to have done economically much better than airlines in alliances in approximately the same period of time.

Again, this research is but a third step in tackling the benefits or otherwise of joining an alliance, from an empirical perspective. Further studies may be needed to explore the performance of airline alliances when taking in to account other performance-related variables, such as operational costs, number of passengers transported, etc.

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