

Glass cockpits in general aviation: A comparison of men and women pilots' perceptions

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Abstract

General Aviation refers to a range of aviation-related activities, individual and businesses, primarily occurring in smaller aircraft and at secondary airports, usually not involving regular public transport (scheduled) services. New technology in the form of advanced cockpit systems is being introduced into general aviation or light aircraft. This research focuses on the perceptions of men and women pilots towards these new systems. This Australian research builds on similar research carried out in the United States of America. The research used a mixed method approach based on an electronic survey. Quantitative data was drawn from the multiple choice questions and the qualitative data drawn from the free comments participants wrote at the end of the survey. The quantitative and qualitative results are used to complement each other in the analysis. The results indicate, as a community of users, both men and women pilots generally have positive perceptions of advanced cockpit systems. Results from the quantitative analyses indicate that men preferred to use advanced cockpit systems significantly more than females. Females also tended to be more concerned about not losing their piloting skills and being dependent on these systems more than men. Qualitative analyses supported these findings. Additional information was also gained through the analyses that suggested that although both males and females were positive and had adopted the new technology, the reasons underlying the use of these was quite different for men and women.

Introduction

Commercial, large jet aviation has been utilising an expanding range of advanced technology such as GPS (Global Positioning System), AP (autopilot), MCDU (multi-purpose control display unit), FMC (flight management computer), EFIS (electronic flight instruments system), PFD (primary flight display), HUDS (heads up displays), on flight decks for over 20 years. This technological application has been labelled the 'glass cockpit' and has been the subject of much research over this period (Wiener, 1988; James, McClumpha, Green, Wilson, & Belyavin, 1991; Rudisill, 1995; Singh, Deaton & Parasuraman, 2001; Naidoo, 2008; Mitchell, Vermeulen & Naidoo, 2009). Similarly, the paucity of women pilots in large commercial jets has been explored (Vermeulen & Mitchell, 2007; Kristovics, Mitchell, Vermeulen, Wilson & Martinussen, 2006; Mitchell, Kristovics, Vermeulen, Wilson & Martinussen, 2005). The new technology continues to be developed and applied to the

military, commercial and the general aviation field. General aviation includes all aviation operations but excludes airlines and military aviation. It includes business flying, agricultural aviation, personal flying for pleasure and sports, bush flying, gliding and flying by flight-training institutions (Kumar, DeRemer & Marshall, 2004). Experimental aircraft and very light jet aircraft are recent additions to general aviation (Cobb, Thomas & Cobb, 2007).

More recently, manufacturers of light aircraft have been introducing versions of this technology, including GPS, AP, and Traffic Alerting System (TAS) into the general aviation (GA) domain. These are referred to as advanced cockpit systems. Advanced cockpit aircraft means any aircraft, old or new, that includes at least a panel-mounted GPS receiver unit and an autopilot. The new cockpit systems might also include electronic flight instruments, a moving map, traffic alerting system, hazardous weather system, terrain warning system, or a complete glass cockpit. Therefore general aviation and recreational pilots are being exposed to a new raft of innovations in light aircraft flight deck design. Recent research (Casner, 2005, 2008; Dekker & Nahlinder, 2006) have examined pilot perceptions of the new technology and some implications for training new pilots. The aims of this research are to develop a greater understanding of the perceptions of pilots, as a community of end users, towards automation on the flight deck of GA aircraft in Australia using this framework. More specifically, the research will address the relationship between women pilots and the new technology and compare their perceptions with that of men pilots.

Women and ‘those flying machines’

Within international, domestic and regional aviation domains there is a paucity of women pilots. Estimates put the numbers to be less than 5% of the world wide total pilot population (Mitchell et al. 2005). In Australia, the current number of licence holders for the piloting of aeroplanes, helicopters and balloons is 40734 men and 2382 women. Women represent 5.85% of all licence holders (Stewart Cameron, CASA, personal communication 26.02.2010). This is an unfavourable comparison with other non traditional occupations such as engineering where, for example in Australia, women comprise 10% of the engineering workforce (Engineers Australia, 2006). The reasons for the low numbers of women entering into the commercial flying field remain unresolved. This is despite more than three decades of affirmative action and equal employment opportunity legislation and organisations providing opportunities for women. In engineering, Faulkner (2006) indicates that women and girls are

not interested in design roles and ‘that the symbolic association of masculinity and technology must be operating strongly’ (p 143). Similarly, Mitchell et al. (2005) found that Australian data indicated a pronounced orientation towards a masculine culture within piloting. This is despite the evidence of legendary women aviators and their contribution to aviation (Moolman, 1981; Cadogan, 1992; Yount, 1995). Thus, piloting remains less attractive to women than other non-traditional occupations including engineering.

The significance of air transportation cannot be overestimated in terms of the economic and social impact to society. From the early days of powered flight women have been involved in its development and acceptance. Women pilots (aviatrixes) help ‘fuelled an immense popular passion for flying and captured the imagination and hearts of the masses’ (Millward, 1998-99:1). It is from this point that women pilots, having demonstrated that flying was safe, began to be marginalised by the aviation industry. Millward’s (1998-99:13) research indicates that women pilots were portrayed either as ‘woman in pursuit of diversion’ and ‘woman in pursuit of fortitude.’ Women between World War 1 and 11 were portrayed as not being serious about the economic rewards of flying but merely flew for sport and pleasure. As a result many women’s contributions to flying were written out of the history of aviation. As Millward (1998-99:14) points out ‘while women can occasionally be incorporated into a masculine discourse, the reverse seldom occurs.’ Airspace, at that time, came to be and remains under masculine control and the domain of men.

Classifying women pilots as either seeking diversion or fortitude helped reinforce the notion that women were not meant to fly aircraft. They were the recipients of gender bias evaluations based on their excursions into a male dominated occupation and ‘man’s work’. These successful women pilots were then subjected to a discourse that favoured male attributes and were therefore criticised for violating gender prescriptive norms (Heilman, Wallen, Fuchs & Tamkins, 2004). For women, stepping outside the bounds of gender specific stereotypes generates forms of social censure including disapproval, negativity, being cold, poor group members and interpersonally wanting. They can be seen as ‘bitter, quarrelsome, selfish, deceitful and devious’ as well as counter-communal (Heilman et al., 2004:417). These negative epithets are usually not applied to the successful man operating in a male gender specific domain. Prototypically, men are applauded for being assertive, competitive, agentic and controlling while women are stereotyped as pro-social and communal (Lammers, Gordijn

& Otten, 2009). This stereotypical bias against successful women pilots lead to their contribution to aviation to be downgraded and/or ignored in the development of aviation.

Not only were women 'written out' of aviation history, aircraft cockpit design was engineered with a bias against women's bodies. This bias was not confined to the military but to commercial aircraft as well. Aircraft cockpits were designed and built to conform to male anthropometry (Weber, 1997). As Araújo (2008:483) points out '[T]he relative subordination of women thus concerns not only the production of technology and science but also its practical utilization.' The design of cockpits has acted as a barrier to the inclusion of women pilots in military and commercial aviation and therefore helped to preserve the cockpit primarily as a male domain. However, in light aircraft, cockpit design had less physical limitations for women. Cockpit space, although always confining, is personal space whether the cockpit seating layout is singular, paired or tandem. Instrumentation, relative to large aircraft, was basic and the required physicality of strength and leg and arm reach required for large aircraft was generally not an issue except for exceptionally short people. But flying has a duality of space. There is the envelopment of the pilot within the aircraft and expansiveness of seemingly unlimited airspace surrounding the aircraft. The duality and use of this airspace then depends upon how it is being utilised by the pilots. It could be because of the pilot being employed and engaged in commercial activity, the pilot's participation in a sporting event, or a pilot engaged in leisure or personal flying.

Women and technology

Feminist studies into the relationship between women and technology have spanned several decades. A critical argument in women's relationship with technology is that technology and its development is male dominated and therefore it enhances men's power. Much of the writing has been based on the premise that '[T]he cultural association between masculinity and technology in Western society is hard to exaggerate' (Grint and Gill 1995:3). Articles on the 'social shaping of technology' or 'constructivist' theory of technology emphasise the dominance of masculinity in the development of technology (Wajcman, 2005). Rather than women being the developers of technology they are mainly consigned to the role of end users, be it in the home or the workplace. Edited books by MacKenzie and Wajcman (1985, 1999), Grint and Gill (1995), Fox, Johnson and Rosser (2006) and Wyer, Barbercheck, Giesman,

Ozturk and Wayne (2009) are some of the many contributions to the understanding of that relationship which embeds technology in a masculine frame.

Feminist writers bring many perspectives to analyses of the interactions between women and technology. Bryson (1999) discusses various approaches and recognises that each approach can be complementary or antagonistic. Similarly, Rosser (2006) recognises that there are many divisions within the feminist approach to understanding the relationship between women and technology. Each perspective brings with it its own 'ways of seeing' and interpreting the impact of technology in such terms as patriarchy, culture, class, power, race, inequality, occupations and structural issues relative to gender. Similarly, other approaches, informed by constructivist thought, include ways of 'doing gender', 'performing gender', 'positioning gender' and 'practicing gender' (Poggio, 2006).

Orlikowski (2000) criticises the social constructivist approach indicating that it does not take into sufficient consideration the role of the end user of technological artefacts, technology-in-practice. She goes on to say

...in both research and practice we often conflate two aspects of technology: the technology as *artefact* (the bundle of material and symbol properties packaged in some socially recognizable form, e.g., hardware, software, techniques); and the *use* of technology, or what people actually do with the technological artefact in their recurrent, situated practices (p 408).

The choice of various technologies and technologies-in-practice, involves both choosing the type of technological artefact and how the user will interact with and apply any number of application. Accordingly, technologies-in-practice are those 'rules and resources' based on the 'skills, knowledge and assumptions' held by the user and developed by their ongoing interaction with the properties and norms or protocols of each artefact (Dery, Hall & Wailes, 2006:232).

On a more psychological level, and one that does not dispute Orlikowski's (2000) argument, are the findings of Venkatesh, Morris and Ackerman (2000) and Venkatesh, Morris, Sykes and Ackerman (2004). They investigated gender differences in individual decision making processes in technology adoption using the theory of planned behaviour as the basis of their studies. Initially, Venkatesh et al. (2000) found that women tended to have what they termed

as a 'balanced' approach to adopting new technology, that is, they were most influenced by subjective norm and perceived behavioural control. In contrast, attitude was the only influencing factor for men. Attitude relates to the perceived ease of use and the usefulness of the technological base being introduced. Subjective norm relates to "perceived opinions of referent others" (Mathieson, 1991, p. 176). Perceived behavioural control relates to perceived "perception of the availability of skills, resources and opportunities" (Mathieson, 1991, p. 176). As Venkatesh et al. (2000) suggest, these findings support the gender schema theory. Their literature review indicated that men were more inclined towards a preoccupation with work, accomplishment of objectives and eminence and were achievement motivated. Other masculine traits included dominance and assertiveness, being instrumental, task-oriented, more likely to rebel, more likely to emphasise outcomes over process. In contrast, they related to women having characteristics such as expressive behaviour, being more compliant in receiving and acting on orders, relationship oriented, interpersonal goals, increased awareness to social cues, a greater process orientation.

One of the limitations of the findings above was addressed by a later study by Venkatesh et al. (2004) who not only explored the difference between men and women based on biological sex, but they also incorporated a measure of gender identity. They found that masculine individuals showed the same pattern above for men, that is, influenced by attitude only. Feminine individuals were most influenced by subjective norm and perceived behavioural control, and where attitude was not significant. However, for androgynous individuals (where participants exhibited both male and female traits), results indicated that attitude, subjective norm and perceived behavioural control were all significant. Their research also showed that a large percentage of females (67%) in their sample could be classified as androgynous. Also, Venkatesh et al. (2000) found that factors such as income, organizational level, education, and computer self-efficacy were all found to be nonsignificant as predictors of intention of use.

Within the context of general aviation which may be considered a masculine industry, the implementation of advanced technological developments, represented by a range of artefacts identified above, presents the opportunity to compare what men and women pilots, a community of users, say they do in relation to the new electronic systems being embedded in light aircraft.

The present study

The present study builds on recent findings (Casner, 2008) carried out by NASA in the USA into GA pilot perceptions of glass cockpits in light aircraft that examined the benefits and limitations of the use of this technology. Casner (2008) identified nine topic areas arising out of the research. These are 1 General attitudes about advanced cockpit systems; 2 Workload; 3 Situational awareness; 4 Learning; 5 Retention; 6 Error; 7 Safety; 8 Preference for in-flight use; and 9 Overall preferences. The focus of the present study, however, is to examine these issues in relation to women pilots in comparison to that of men's perspectives and is based on data collected from an Australian sample.

The research used a mixed method approach. Quantitative data was drawn from the multiple choice questions and the qualitative data drawn from the free comments participants wrote at the end of the survey. In this approach the quantitative and qualitative methods are used in conjunction with one another. Results from both areas are integrated and are aimed to complement each other (Steckler, McLeroy, Goodman, Bird & McCormick, 1992).

Method

Participants

Overall, there were 223 responses. These were from 186 men, 34 women pilots and 3 did not indicate their gender. Not all respondents completed their survey forms. Incomplete surveys were removed from the database and the final cohort consisted of 100 men and 22 women pilots. Table 1 highlights their biographical details.

Table 1: Participant details

	Women (N=22)	Men (N=100)
Average age	44.8	51.9
Average flight hours	1289	2679
Average hours in 'glass cockpit'	72	403
Average hours with at least a Panel mounted GPS	286	740
Certificates and ratings		
1. Private	12	51
2. Instrument	-	16
3. Commercial	5	23
4. Airline Transport Pilot	2	9
5. Chief Flying Instructor	2	-
6. Chief Flying Instrument-Instructor	1	1
Primary flying activity		
1. Non –schedules charter	6	11
2. Scheduled charter operations	-	-
3. Airline	1	3
4. Private leisure/sport	14	84
5. Other	1	2
Education		
1. High School Certificate	4	30
2. Diploma	5	23
3. Bachelor degree	6	24
4. Post graduate degree	7	23
Computer literacy		
1. Poor	-	-
2. Average	5	18
3. Above average	5	39
4. Excellent	12	43

Materials

The present study used the identical 52-item NASA survey on pilot attitudes towards glass cockpits. Participants were asked to respond to each item using a 5-point Likert scale, where 1 = strongly agree, 2 = agree, 3 = neutral, 4 = disagree and 5 = strongly disagree. Therefore, the lower the score, the more the pilots agreed with the statement represented by the item. One further item “How do you think advanced cockpit systems will affect the number of aircraft accidents?” had a different response set. Participants had to choose from 6 responses, that is, ‘significantly reduce accidents’, ‘somewhat reduce accidents’, ‘will not affect accidents’, ‘somewhat increase accidents’, ‘significantly increase accidents’ and ‘unsure’.

In addition, further items gathered data related to primary flying activity (eg. private/leisure, scheduled charter operations etc), age, sex, educational background, certification and total flight time, including time flying with a glass cockpit. Participants were also asked about their preference between the different advanced systems, such as GPS, autopilot, hazardous air display, moving map, terrain warning and traffic alerting system. Further, a space for comments was added to allow pilots to express their views on issues that were or may not have been addressed in the survey questions. These comments were then utilised as the base for the qualitative analyses. The NVivo 8® software package was utilised to analyse the qualitative data.

Procedure

The data was collected online via links placed on the websites of the Aircraft Owners and Pilots Association (AOPA), Australian Women Pilots' Association (AWPA), Sport Aircraft Association of Australia (SAAA) and Recreation Aviation - Australia (RAA). Each of these associations advised members of the research and requested that they complete the survey. Responses were submitted online and collated on Excel spreadsheets.

Results

Quantitative

The data from the 52-item questionnaire was analysed using SPSS 17. The original intention of performing a factor analysis on the questionnaire was not possible owing to the small size of the sample. In reviewing the required sample sizes for factor analyses, Mundfrom, Shaw and Ke (2009) state that the minimum that has been suggested was 3 per item, which for the 52-item questionnaire would be a minimum of 156 participants. Unfortunately, the present sample of 122 prohibited analysis for the factor structure. Therefore, the following analyses were undertaken on an item-specific basis.

When sample sizes are uneven, as in this case of the present study where there are 100 men and 22 women, most statisticians recommend the use of non-parametric tests such as Mann-Whitney tests (Kikvidze and Moya-Laraño, 2008). However, when Kikvidze and Moya-Laraño (2008) compared these two procedures with uneven sample sizes and unequal variances, they found that the t-tests produced lower percentage of Type I error rates compared to the Mann-Whitney tests. There was little difference between the two procedures

for Type II error rates. Simply, Type I errors refer to seeing a difference between 2 samples when there is none (false positives) and Type II error refers to not seeing a real difference between two samples when there really is a difference (Borg and Gall, 1989). Therefore, the following analysis on the items was undertaken using independent t-tests which, according to Kikvidze and Moya-Laraño (2008) would reduce the incidence of 'false positives'.

In relation to which advanced cockpit system males and females preferred, the majority of both males and females preferred the GPS. For females, 63.6% preferred the GPS, 9.1% selecting autopilot and 9.1% selecting the moving map. Males showed a similar pattern, where 54% chose the GPS, 19.0% selecting autopilot and 19.0% selecting the moving map. More females preferred (13.6%) the traffic alerting system than men (4%). Hazardous air display systems were preferred by 3% of males and 4.5% of females.

The item of whether advanced cockpits would increase or decrease accidents was scored from 1 = significantly decrease accidents to 5 = significantly increase accidents (no-one had chosen unsure). The result from an independent t-test with α set at .05 showed no significant difference between males and females, $t(120) = .21$, $p = .83$. The mean for men was 1.88 (SD = .33) and the mean for women was 1.86 (SD = .35), indicating that both men and women thought that advanced cockpit system would somewhat to significantly decrease accidents.

Table 2 shows the items of the questionnaire and the difference between the means for men and women pilots. As can be seen from the Table, 11 of the items showed a significant difference between males and females. All analyses on the items below were undertaken using independent t-tests with α set at .05. Items 1, 8, 43 and 48 were analysed using the t-test for unequal variances because of violation of the assumption of homogeneity.

There were 5 items in which the men's scores were significantly different to women's scores, indicating that men agreed more with the statement than women on the following items.

Item 1. Using the autopilot lowers my workload, $t(35.77) = -3.019$, $p = .005$.

Item 4. My situational awareness is better in an advanced cockpit, $t(120) = -2.051$, $p = .042$.

Item 12. I prefer to use the autopilot during a missed approach procedure, $t(120) = -2.004$, $p = .047$.

Item 21. I prefer to use the autopilot when flying en route, $t(120) = -2.042$, $p = .043$.

Item 34. I feel safer in an advanced cockpit aircraft than I do in a conventional aircraft, t(120) = -2.296, p = .023.

Women's scores were significantly different to men's scores on 6 of the items. Women agreed more with the statement than men on the following items:

Item 2. New pilots that learn to fly only in advanced cockpit aircraft are going to be lacking in some important piloting skills, t(120) = 2.426, p = .017.

Item 3. I am concerned that I might become too dependent on GPS, autopilots, and other advanced cockpit systems, t(120) = 2.473, p = .015.

Item 8. CASA should publish a new pilot handbook to cover advanced cockpit systems, t(43.14) = 3.332, p = .002.

Item 26. I need to fly more often to maintain proficiency in an advanced cockpit than I do in a conventional aircraft, t(120) = 2.774, p = .006.

Item 43. For some pilots, turn off their GPS and moving map during a flight, and they might be lost, t(51.75) = 3.131, p = .003.

Item 48. Advanced cockpit systems can get you into trouble just as easily as they can get you out of trouble, t(38.53) = 2.938, p = .006.

Table 2. Differences between male and female responses

Variables	Males (100)		Females (22)		Sign
	Mean	SD	Mean	SD	
General attitudes					
9 Advanced cockpit systems are becoming too complicated	3.18	1.09	3.05	.90	ns
14 They've gone too far with advanced cockpit systems	3.77	.98	3.59	.91	ns
17 I look forward to new kinds of advanced cockpit systems	2.14	.93	2.41	.96	ns
22 The advanced cockpit does not make good use of my basic piloting skills	3.07	1.11	2.77	1.15	ns
30 In an advanced cockpit, sometimes I feel more like a 'button pusher' than a pilot	3.35	1.11	2.91	1.11	ns
48 Advanced cockpit systems can get you into trouble just as easily as they can get you out of trouble	2.46	.98	1.91	.75	p = .006
Workload					
1 Using the autopilot lowers my workload	1.62	.69	2.05	.57	p = .005
7 There are too many alerts and warning noises in the advanced cockpit systems	3.36	1.00	3.09	.92	ns
28 I can better control my workload in an advanced cockpit	2.43	.91	2.73	.93	ns
37 I sometimes spend more time setting up and monitoring the autopilot than I would just hand-flying the aircraft	3.29	.98	2.82	1.05	ns
42 Navigating using GPS lowers my workload	1.87	.66	2.27	.93	ns
Awareness					
4 My situational awareness is better in an advanced cockpit	2.33	1.21	2.91	1.20	p = .042
15 I always know what mode the GPS and autopilot are in	2.25	.95	2.32	.84	ns
23 The pilot that uses pilotage (a sectional chart) is going to have better navigational awareness than one who uses a GPS and moving map display	3.15	1.18	2.77	.97	ns
24 It worries me that the GPS, autopilot, or other systems may be doing something that I don't know about	3.38	1.00	3.00	.93	ns
25 When I have a traffic alerting system on board, I look out the window less often	3.51	.99	3.23	.92	ns
29 If you turn off my GPS and moving map during a flight, I may be lost	3.95	.88	3.77	1.11	ns
33 Pilots who use traffic alerting systems have a tendency to look out the window less often	3.00	.98	2.68	.78	ns
43 For some pilots, turn off their GPS and moving map during a flight, and they might be lost	2.43	1.04	1.91	.61	p = .003

Learning

2	New pilots that learn to fly only in advanced cockpit aircraft are going to be lacking some important piloting skills	2.51	1.08	1.91	.92	p = .017
8	CASA should publish a new pilot handbook to cover advanced cockpit systems	2.63	1.14	1.95	.78	p = .002
16	There are many things about advanced cockpit systems that can only be learned through experience flying the aircraft	2.01	.77	2.09	.87	ns
19	The practical test standards need to be expanded to include skills specific to advanced cockpit aircraft	2.26	.92	2.00	.87	ns
20	There is more for me to learn and remember in an advanced cockpit aircraft	2.34	.90	2.00	1.02	ns
38	There are still features of the advanced cockpit that I don't understand	2.53	1.06	2.09	.92	ns
39	I found everything that I needed to know about advanced cockpit systems in the manufacturer's technical manuals	3.07	1.08	3.27	.88	ns
41	Students learn to fly GPS approaches more quickly than they learn to fly VOR, VOR/DME, and localizer approaches	2.81	.71	2.64	.49	ns
44	The CASA pilot knowledge test (aka 'written exams') should include questions about advanced cockpit systems	2.54	1.00	2.77	1.02	ns
47	The CASA has provided pilots, students, flight instructors, and examiners with sufficient guidance about flying advanced cockpit aircraft	3.35	.78	3.59	.67	ns
51	Pilots should not be allowed to act as PIC in advanced cockpit aircraft unless they get an endorsement similar to the one required for high-performance and complex airplanes	2.79	1.16	2.32	1.09	ns

Retention

3	I am concerned that I might become too dependent on GPS, autopilots, and other advanced cockpit systems	3.12	1.05	2.50	1.14	p = .015
26	I need to fly more often to maintain proficiency in an advanced cockpit than I do in a conventional aircraft	3.00	1.08	2.32	.84	p = .006
32	I am concerned that flying advanced cockpit aircraft will cause my basic flying skills to deteriorate	3.33	1.10	3.00	1.02	ns
36	I am concerned that today's pilots may become too dependent on GPS, autopilots, and other advanced systems	2.70	1.07	2.50	1.14	ns

Error

5	Advanced cockpit systems are going to reduce the number of errors pilots make	2.85	1.09	3.05	1.13	ns
6	Using GPS is going to result in fewer accidents	1.98	.91	2.09	.92	ns
10	Incorrect data entered by mistake is easy to detect in the advanced cockpit	3.27	.95	3.50	.74	ns
11	I am less likely to make a navigational error or bust an altitude in advanced cockpit	2.44	1.10	2.50	.96	ns
31	Advanced cockpit systems create opportunities to make new kinds of errors	2.22	.94	2.00	.62	ns

Safety

13	I feel safer in any aircraft that has a parachute (ballistic recovery system) for the airframe	3.08	1.14	3.00	1.23	ns
34	I feel safer in an advanced cockpit aircraft than I do in a conventional aircraft	2.84	.98	3.36	.90	p = .023
45	Terrain displays in the cockpit are going to reduce the number of controlled flight into terrain (CFIT) accidents	2.44	1.05	2.50	.86	ns
46	Some pilots will misuse advanced cockpit systems to stretch the boundaries of safety	2.21	.87	2.05	.84	ns
49	Traffic alerting systems are going to reduce the number of mid-air collisions	2.44	.97	2.32	.72	ns
50	Cockpit weather systems are going to reduce the number of weather-related accidents	2.39	.97	2.36	.85	ns
52	GPS is going to reduce the number of accidents	2.92	.98	3.14	1.04	ns

Preference for in flight use

12	I prefer to use the autopilot during a missed approach procedure	3.17	.92	3.59	.73	p = .047
18	I prefer to use the autopilot during periods of high workload	2.00	.94	2.36	.85	ns
21	I prefer to use the autopilot when flying en route	2.09	.93	2.55	1.01	p = .043
27	I would rather use GPS than VORs to navigate	2.05	1.02	2.00	.97	ns
35	I prefer to use the autopilot when flying an instrument approach	2.86	.93	3.14	.71	ns
40	I prefer to hand-fly the aircraft (autopilot off) during periods of low workload	2.68	.99	2.32	.89	ns

Qualitative

Various qualitative analysis procedures and interpretive techniques are available. In order to bringing structure and meaning to the large volume of collected data in this study it was decided to employ computer-aided qualitative data analysis software. This is typically used in projects that have non-numerical, unstructured data, such as data in the form of text, e.g. transcripts from interviews, essays, written comments, graphics and other multimedia formats. NVivo 8® is software program for qualitative text analysis and is designed to assist researchers organize, manage, code and analyse qualitative and mixed-methods research data. This program can be used to facilitate the uncovering of the multifaceted themes hidden in the data or to allocate the data to predetermined categories.

Written responses by men (63/185: 34%) and women (13/38: 34.2%) were extracted from the survey. The qualitative analysis was conducted through NVivo 8®. Casner's categories were entered as tree nodes and the content of the comments allocated to the various nodes. In addition to the tree nodes, 'child nodes' or subcategories were added to the tree nodes of General Perceptions, Retention and Safety. These child nodes were Positive and Negative Perceptions, Reduced Skill Levels, and Decreased Safety respectively. These were added to reflect the varying perspectives that were identified within the comments.

Comments made by both men and women pilots tended to be brief and focussed on particular aspects of the technology and its application. This amount of qualitative data has limited the analysis and therefore the results can be considered exploratory rather than definitive.

General perceptions about advanced cockpit systems

The qualitative analysis revealed a mixture of both positive and negative perceptions of advanced cockpit systems. Both men (21 comments) and women (3 comments) pilots were mainly positive in their perceptions about the cockpit systems. Comments from men included 'Glass Cockpits are awesome', 'the glass cockpit makes me more confident in the systems I am trusting to keep me in the air', 'I believe that Glass cockpits will make better pilots. There is no guessing or any confusion, you can never have enough information', and 'I would prefer a glass cockpit because you get more performance figures that you can manage in-flight.' Women pilots had fewer comments, however the indication was that 'they can only enhance the flight.' While both groups of pilots were generally positive some expressed reservations

about the new technology. Typically, men said 'I believe they are of benefit, but can cause us to be a bit reliant', 'glass moving may etc is great but I am wary of me and my pilots becoming too reliant on it', while women indicated that 'Glass cockpits are inherently neither good or bad' and that 'if the pilots use them as they should be used.' These comments indicated that perceptions were positive however there were some reservations about their efficacy and use.

With fewer comments (8) on the negative side the focus for men was that 'Glass cockpits are a distraction' and that there were difficulties operating across different brands. For example, 'Glass cockpit ie Garmin 1000 etc is vastly different to Advanced cockpit ie Autopilot, VOR, GPS' and 'glass cockpits could be more intuitive, and standardised across brands' and 'Glass cockpits should resemble analog (sic) cockpits with as little button pushing as possible.' Women pilots (2) commented 'I really don't find digital displays do much for me, the analogue dials give me a really good indication of what's going on ... and I don't have to worry much about electrical failure etc', 'each system is very different both in display and controller requirements' and 'Will be just as lethal in the hands of cashed up private pilot who has minimal ability or understanding and big ego.' Among both men and women pilots there is a cross section of perceptions about the new technology being installed in general aviation aircraft. Overall these perceptions are positive but with some doubts being raised as to their efficacy and to the standardisation of the operation and displays of various brands.

Workload

Pilot workload is an issue across all fields in the aviation domain and the survey sought comments on how advanced cockpit systems may affect workload were examined. Workload in the aviation domain 'refers to the combined mental and perceptual demands imposed by the time critical pressures of the flight environment' (Hitchcock, 1999:313). Only men respondents (6) commented briefly on workload in a positive manner. 'Any device that reduces pilot workload (especially in SPIFR) makes for safer flight', 'Anything that has the potential to reduce workload and provide good positive feedback to pilots is worthwhile ... a glass environment reduces workload and makes the task much easier' and a warning 'the increased sophistication and complexity of cockpit systems for the pilot (who now has to act as computer operator in addition to PIC [Pilot in command]).'

Situational awareness

Flying an aircraft requires the pilot or pilots to maintain a high level of situational awareness. Situational awareness is 'the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning and the projection of their status in the near future' (Endsley, 1999:258). On the positive side men pilots (10) gave recognition to the enhancement of situational awareness. Comments included 'The benefits of improved situational awareness in advanced cockpit aircraft are beyond dispute', 'just upgraded to a full glass panel to improve safety and situational awareness' and 'Very expensive, but it has greatly enhanced situational awareness.' Again, words of caution were evident. 'Glass offers significantly enhanced geographical situational awareness ... but also breeds complacency about looking out the window', 'I don't think glass cockpit technology enhances PIC situational awareness', 'Glass cockpits, apart from readability, if taken to far can focus attention inside the aircraft instead of outside', 'I worry that in busy airspace pilots will tend to use/look/play/admire their electronic systems instead of keeping a good lookout' and 'They should be looking outside, not watching TV.' Similarly, women pilots (2) were reticent about the improvement in situational awareness. 'In saying that, the moving map I'm used to seeing is used purely for situational awareness and never relied upon' and 'I am concerned that there will be too much "heads inside" rather than looking outside.'

Learning

In this survey Learning refers to how advanced cockpit systems might affect the way pilots train and maintain proficiency. This category attract the most overall comments with men (20) and women (11) raising issues about training in advanced cockpits systems. Clearly, the emphasis on training indicated that pilots were aware of the need for in-depth training to acquire the appropriate level of knowledge about the various electronic systems. Arising out of this, a major concern from both men and women pilots was the lack of a formalised training programme for advanced cockpit systems together with a subsequent licence endorsement from the Civil Aviation Safety Authority (CASA). One woman commented 'A glass cockpit needs a rating like IF flying'. Others commented 'CASA or the respective flying schools utilising Glass cockpit aircraft need to run ground courses and practical courses that let the student know the limitations of their instruments' and 'CASA could develop an online course for providing further instruction.' 'CASA, operators and pilots need to work together to ensure pilots are familiar with the operations of each specific system' and 'Suggest it

would be difficult for CASA to do much in terms of ground study because each system has its own idiosyncrosies (sic). The existing requirements for use of GPS/RNAV under IFR are a bit of a joke - if they were serious they'd require a ground school for each specific type of GPS system' were from men pilots.

Both men and women pilots gave indications that training in conventional cockpits should precede training on advanced systems. Comments from women included 'In the initial stages of flying I believe traditional methods of navigation etc should always be the foundation of knowledge with more technologically advanced methods maybe being introduced to complement that later down the track', 'I believe new pilots should be trained using old 'steam gauges' and only after a period of learning should glass cockpit instruments be introduced' and 'I think that the PPL licence should include training in the use of GPS.' Men said 'all pilots need to learn normal analog (sic) cockpits first', 'Ground familiarisation (aka the Garmin simulator) is invaluable', 'I think that it is beneficial for pilots to be trained on basic instrumented aircraft before they fly with moving map displays etc' and 'Learning glass cockpit operations after being trained on the older analogue instruments, is part of the on going learning experience of aviation.'

Retention

Retention is about retaining knowledge and skills related to advanced cockpits. Here again, both men (15) and women (2) pilots had mixed views on the impact of advanced cockpit systems on the retention of knowledge and flying skills. Women pilots said 'It is the skill level of the operator which determines how effective it is. I love "glass" but am concerned that little use of functions may be easily forgotten and hard to call upon when urgently needed' and 'having all the electronics in the world will not stop a pilot from ignoring the systems (alarms), it may encourage some to become slack with their flying skills.' Men pilots indicated that 'Like everything else, there will be enormous variation between individual pilot aptitudes in adapting to the capabilities of advanced cockpits', 'I try to maintain basic skills, but when busy sometimes you do just rely on the equipment' and 'any of these type of technology are an aid to the pilot but should not replace proper piloting skills/training or proper airmanship.'

Other male pilots were more direct ‘Yes, we see basic pilot skills getting worse from people who have only learnt in a glass aircraft – particularly nav. yes, their situational awareness is often better from good use of glass.. until it goes blank’, ‘Currency is important when using the systems, particularly where IFR flight is concerned. The current trend towards providing low time students with advanced avionics should be considered as it could definitely (sic) result in pilots with reduced piloting skills’ and ‘However i (sic) see limited hour pilots place too much reliance on the automated systems and they do not learn airmanship or handling capabilities in an emergency situation. Map reading skills also disappear rapidly after licence qualification.’

Error

Error refers to how advanced cockpit systems will affect pilot error. This area attracted the least number of comments and only by four men. Comments included ‘Poor pilot decision making/choices will still be the reason for most accidents ... but unfortunately people will find ways to make new errors and dumb choices’, ‘The problem with planes with glass cockpits is that different brands of glass cockpits can have subtle differences in the way they operate. This can cause confusion when flying different planes’, and ‘Some pilots, regardless of what is occurring in and out of the cockpit will end up crashing because they fail to manage themselves wisely.’

Safety

Safety is a high priority in aviation. The survey sought to examine pilots’ belief about how advanced cockpit systems would impact on safety. Thirteen men and no women pilots addressed the issue of safety in their comments. Again, their comments reflected mixed perceptions concerning the safety aspects of the glass cockpit. Positive comments included ‘Technology should help to decrease accidents’, ‘Technology provided by the advanced cockpit is of great benefit for safe piloting’, ‘I fly high performance single with GPS moving map advanced autopilot and weather at command instrumnt (sic) and have just upgraed (sic) it top a full glass panel to improve safety’ and ‘can only see it as good and positive move to safer flying.’ Others appear more reticent, saying ‘I believe the systems to be much safer, however i (sic) see limited hour pilots place too much reliance on the automated systems’, ‘makes for safer flight in IMC but there will always be mavericks and mncho (sic) men doing

it the hard way' and 'The attitude and professionalism of the pilot has more to do with safety of flying either system.'

Others saw the use of advanced cockpits the potential for a decrease in safety. 'Without having duplicated "glass" systems I am not yet convinced that the same level of safety is obtained', 'Most mid air collisions in Australia are at GAAP reporting points and traffic alerts will not reduce them', 'VFR is see and avoid, not to be "told" that there is something there and then avoid it' and glass cockpits have 'the potential for distraction.'

Preference for in-flight use

This examined pilots' preferences for when to use advanced cockpit systems during flight. Pilots had little to say in when they actually used the systems. Comments such as 'The auto pilot allows for vertical navigation and go around', 'I recently fitted the Dynon auto pilot which makes cross country so relaxing', 'I have Storm Scope, which is seldom used, but essential when it is' and 'While I have a gps I only use it as a back up, not as my main navigational aid.' These comments came only from the men pilots with no comments from women.

Discussion

The main focus of the present study was to explore the possible differences between men and women on Casner's (2008) new measure of pilot attitudes towards advanced cockpit systems. Although the primary objective was to confirm Casner's proposed factors, the few numbers of pilot responses, however, prohibited this analysis. Therefore, differences between males and females were undertaken on items rather than Casner's proposed factors.

While elements of the advanced technology are available ranging from a GPS system to a full glass cockpit men and women pilots have both similar and differing perceptions of the application of and benefits associated with its use. The use of such technology is predicated upon a level of computer literacy. Both men (82%) and women (77.3%) rated themselves above average or excellent in computer literacy. No one rated themselves as poor. Therefore respondents could be assumed to have a familiarity and experience in the use of these artefacts.

By adopting Mathieson's (1991) definition of attitude to technology-in-use, that is, the perceived ease of use and its usefulness, then men found it more useful in terms of lowering their workload (item 1), increasing their situational awareness (item 4), an aid during missed approach procedure (item 12) and flying en route (item 21). However, these comments relate to usefulness rather than perceived ease of use. In General Perceptions, qualitative analyses of men's comments revealed that although men found these advanced systems more useful, they were also concerned about becoming too reliant on them. Qualitative analysis also revealed that there were difficulties in moving from one brand to another which may impact on the relative ease of use. This also raises the question whether a larger sample of men would indicate that there were more opportunities in the use and purchase of other systems, relative to the smaller sample and possible opportunities for females. Thus, future studies may need to include different number of trialled systems and whether this may have an influence on perceptions of ease of use.

Quantitative analyses also revealed that women were more concerned than men in relation to losing some important pilot skills, both in general (eg. items 2, 3, 43) and in their own flying (item 26). Past studies have indicated that male perceptions of female pilot's ability led to them being more 'accepted' by males. Davey and Davidson (2000) found that 'By demonstrating a high level of skill, the first female pilots were able to establish reputations for themselves as good pilots' (p. 207). Additionally, Moore (1999) found that women in a masculine occupation (police in her study) developed a greater sense of occupational identity when participating in professional courses. Thus, pilots' attitude towards technology-in-use (Mathieson, 1991) may be more complex than initially proposed, that is, it may well need to consider aspects of perceptions of 'value' within a person's occupational identity as indicated for female pilots.

In line with the above, women pilots were concerned with both Learning and Retention. Items 2 and 8 in Learning and items 3 and 26 in Retention were statistically different. Women displayed concern for both themselves and other pilots in asserting that there should be more training and possible certification for advanced cockpit systems. The concern for learning was matched by the recognised need for retaining the operational information required to maintain currency on their licence and the use of the artefacts when flying. In terms of technology-in-

practice many women pilots lacked the same level of experience as that of the men (see Table 1). While generally positive over a range of items women recognise the need for improved and follow up training to assist in the retention of skill and knowledge. This view is supported by the National Transportation Safety Board (NTSB) in the United States of America (NTSB, 2010). Familiarity with the artefacts, developed through training and practice assists in developing confidence in the pilot's ability to recognise and deal with the various situations they may face.

Safety within aviation is of primary concern to all sectors of the domain. For item 34, men's score was significantly different than women, indicating that they felt safer in an aircraft with advanced cockpit systems. There was a general belief that the introduction of advanced cockpit systems would result in the reduction of mid air collisions, weather related and accidents in general. There was also concern that some pilots would stretch the boundaries of safety using the new cockpits. Words of warning were made in respect of too much reliance on the systems and the attitude of pilots. However, the lack of any female responses for error and safety aspects in the qualitative findings can either indicate that men were more concerned about these aspects or that the women had already indicated their attitude about this through other means. For example, women agreed more than men on item 48, 'Advanced cockpit systems can get you into trouble just as easily as they can get you out of trouble'. On face value, this item may reflect a safety or error perception, but this item was part of the General Attitude factor. Thus, the need to confirm the factors proposed by Casner (2008) becomes necessary.

While both men and women felt that advanced cockpit systems would decrease accidents, recent preliminary research by the NTSB has indicated that single engine light aircraft 'had no better overall safety record than airplanes with conventional instrumentation' (NTSB, 2010). Their study covers the accident rates of over 8,000 light aircraft between 2002 and 2006. In this study it was found that there was a higher fatality rate in aircraft with advanced cockpit systems than that of similar airplanes with conventional or round dial instruments. The enquiry recommends additional training and endorsement of licences, a position strongly supported by women pilots in the survey. However, the situation may be more of one where pilots become too complacent or prone to risk-taking when using these new devices, an aspect

that was suggested by both males and females in the qualitative analysis. This situation was most apparent in the research undertaken by Casner. He states:

In a previous study, pilots who used GPS and moving map displays estimated their navigational awareness to be greater than that of pilots who navigated using a sectional chart and pilotage in a conventional cockpit (Casner, 2005). Believing their awareness to be superior in the presence of a GPS and moving map, these pilots appeared to assume a less active role in the navigation process. When put to a practical test of navigational awareness, these pilots in fact performed worse than pilots who used pilotage to navigate, and quickly lowered their awareness estimates. Pilots who navigated using a sectional chart and pilotage performed better than they expected, and subsequently raised their estimations of their own awareness (Casner, 2005). These results suggest that pilots' beliefs and attitudes about advanced cockpit systems can sometimes be powerful determinants of pilot behavior and performance in the cockpit" (Casner, 2008, pp.88-89).

Casner (2008) further adds that pilots in their research acknowledged some of the pitfalls of the advanced cockpit systems and that an important part of training should be to help pilots to 'more accurately assess their own vulnerabilities' (p. 110).

While these results give an indication of differences in perceptions there is a limitation in the data due to the small numbers of women pilots who responded, the discrepancy in numbers between men and women in the ratio of 5:1. Given that females represent less than 6% of the total number of licensed pilots in Australia research in this domain will continue to have these small numbers. Another limitation seems to be the concept of previous experience using an advanced cockpit system. One may question what kind/s of advanced system has been used and for how long, as well as experience with different brands. On average, females have less experience in a glass cockpit and flying with at least a panel-mounted GPS (as seen in Table 1). Unfortunately, there is little information to indicate whether this is because they are not interested (thus affecting behavioural intention) and prefer to use the conventional cockpit. Other aspects may relate to whether they may or may not have the funds to purchase the equipment or whether they have only used one brand of equipment. Although gender may have an impact on the possible adoption of new technology and, therefore, short-term use, Venkatesh et al. (2000 and 2004) indicate that both biological and psychological gender did not have an effect on long-term use. However, short-term use was the only factor that influenced long-term use of new technology.

Conclusion

The present study provided an opportunity to compare the perceptions of men and women pilots in respect of the new technology being incorporated in general aviation aircraft. Generally referred to as advanced cockpit systems or glass cockpits, there is an expanding range of artefacts that are available or that pilots are using in their flights. For men and women pilots, technology-in-practice is routinely enacted in every flight. Pilots may choose, or not choose, to use an artefact but if they do so then they are deliberately choosing how they will interact with that artefact (Orlikowski, 2000). This is evident in the quantitative and qualitative responses to the survey.

While generally positive towards the use of artefacts both men and women were selective in when and how to use the technology particularly the autopilot. Comparison of the qualitative and the quantitative data indicates that both men and women pilots, as a community of users, tend to have a general positive perception of the new advanced cockpit systems.

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