CRANFIELD UNIVERSITY

Peter Wilson

Factors Leading to the Degradation of Manual Flying Skills Amongst Airline Flight Crew

School of Engineering/Department of Air Transport

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Supervisor: David Barry

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Abstract

In the aftermath of several recent loss of control accidents, much has been discussed about the decline in pilots' manual flying skills. Previous studies have been able to measure manual flying performance and show *how* it has declined. Yet there has been little research conducted to investigate *why* some pilots may be reluctant or unable to practice manual flight.

A survey gathered qualitative and quantitative data from 883 current airline and business jet pilots from a variety of backgrounds. This was in order to ascertain pilots' own perceptions of manual flying skills and investigate their awareness and susceptibility to any degradation of them. The number and types of events where manual flight has been required, such as failure of aircraft systems or external factors, were also identified. The amount of manual flying which pilots perform was also studied, with differences apparent between various sub-groups, such as region, type of operation and pilot function. Pilots' perceptions on the design of current aircraft systems relating to manual flight, specifically low speed and high angle of attack situations, were also investigated as well as monitoring and training issues.

Results indicated a significant proportion of pilots have experienced a degradation of their manual flying skills and almost all pilots are aware that their skills will decline if they are not practiced. The majority of pilots have also experienced aircraft system failures and external events which required manual flight.

A number of human factors related issues were also identified which may prevent some pilots from practicing manual flying, such as fatigue, lack of confidence, different automation policies of operators and fear of triggering a Flight Data Monitoring event.

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List of abbreviations

ADIRU	Air Data Inertial Reference Unit
AHRS	Attitude and Heading Reference System
AOA	Angle of attack (alpha)
AP	Autopilot
AQP	Advanced Qualification Program
AT	Autothrottle/Autothrust
ATC	Air Traffic Control
ATP	Airline Transport Pilot
ATPL	Airline Transport Pilot Licence
ATQP	Alternate Training Qualification Programme
BASI	Bureau of Air Safety Investigation
BEA	Bureau d'Enquêtes et d'Analyses (France)
CAA	Civil Aviation Authority (UK)
CAT	Clear Air Turbulence
CPL	Commercial Pilot Licence
CS	Certification Standard
EASA	European Aviation Safety Agency
EBT	Evidence Based Training
ECA	European Cockpit Association
ECOTTRIS	European Collaboration On Transition Training Research for Increased Safety
EFIS	Electron Flight Instrument System
FAA	Federal Aviation Administration
FAR	Federal Aviation Regulation
FCC	Flight Control Computer
FCTM	Flight Crew Training Manual
FD	Flight Director
FDM	Flight Data Monitoring
FDAP	Flight Data Analysis Programme
FO	First Officer
FOQA	Flight Operations Quality Assurance
FMA	Flight Mode Annunciator
FMC/FMS	Flight Management Computer/System
FMGS	Flight Management and Guidance System
GPWS	Ground Proximity Warning System
IFR	Instrument Flight Rules
ILS	Instrument Landing System
INS	Inertial Navigation System
IMC	Instrument Meteorological Conditions
LOE	Line Operational Evaluation
LPC	Licence Proficiency Check
LST	Licence Skills Test
MEL	Minimum Equipment List
MPL	Multi Pilot Licence
NextGen	Next Generation Transportation System
ND	Navigation Display

NTSB	National Transportation Safety Board (USA)
PF	Pilot Flying
PFD	Primary Flight Display
PM	Pilot Monitoring
PNF	Pilot Not Flying
PRNAV	Precision-Area Navigation
RAeS	Royal Aeronautical Society
RMT	Rule Making Task
RVSM	Reduced Vertical Separation Minima
SA	Situational Awareness
SAFO	Safety Alert For Operators
TCAS	Traffic Collision Avoidance System
TRI/E	Type Rating Instructor/Examiner
ULR	Ultra Long Range

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Chapter 1 Introduction

1.1 Introduction

Loss of control in flight is now the most significant cause of fatal accidents amongst commercial transport aircraft (EASA, 2010; Boeing, 2012; CAA, 2013). Relatively recent accidents such as the Asiana Boeing 777, Air France Airbus A330 (AF447) and the Colgan Air Dash 8 Q400, would most likely have had more positive outcomes if the crews had demonstrated and applied a (higher) level of monitoring and manual flying skill.

Manual flying ability is just one of many of the technical and non-technical skills that a pilot should possess. Attributes such as teamwork, effective communication, leadership, judgement and decision making are also key.

Vast amounts of information have been produced about flight crew reliance upon automation during the last 40 years, yet automation related incidents and loss of control accidents are still prevalent. In today's aviation environment where costs need to be controlled more than ever, automation is of immense benefit in achieving accurate and efficient/optimum flight profiles, saving time and fuel along with increases in operational capability.

It is evident that the industry is faced with an extremely important issue with regards to automation (and training for it) and *how* it has affected manual flying. The main context of this research is to establish the factors *why* some aircrews have become so dissuaded from practicing manual flight and going "back to basics", as well as to establish their awareness levels of manual flying skill degradation.

Where this research will differ from previous studies is that it will collect data from pilots worldwide operating a range of aircraft types. Previous studies have generally used participants from a single source and generally one aircraft type. This study will also examine the human factors issues which possibly deter pilots from being able to fly manually. It is also hoped to ascertain the number and type of events that have occurred to a group of pilots which led to manual flight being required.

In order to clarify what manual flight is for the purposes of this study, it may be described as: control of an aircraft flight path without the use of automated functions (such as an autopilot or autothrust system). It may be also taken to a further level, which is flight without guidance cues available from a flight director system.

Situations where manual flight is required may occur without warning, be it due to a technical failure of an automated aircraft system (see figure 1.1 as an example) or an external event. However, when the automation fails, it is wholly reasonable to expect a trained pilot to be able to fly their aircraft within its normal flight envelope. A "non-normal" or emergency situation is neither the time nor the place for a pilot to start rediscovering lost skills. In such situations pilot workload will be increasing, but it should not be to the point where either control of the aircraft or its flight path is compromised.

Figure 1.1 An in-flight system failure of the primary flight instruments requiring manual flight using standby instruments. (Photo: Author)

It is suggested that flying manually requires increased cognitive demands in some situations when compared to automated flight (Ebbatson, 2009). If a pilot is in current manual flying practice, then the cognitive demands they experience may be less than a pilot who is not current. A more current pilot would then have more ‘mental capacity’ available if they found themselves in a situation that required manual flight.

Obviously there are situations where practising manual flying skills may decrease safety margins and increase workload for the monitoring pilot, such as in very congested airspace or inclement weather conditions.

The opportunities to practice manual flight are becoming limited, with RVSM airspace and the increasing number of airport P-RNAV departures and arrivals, which mandate the use of a certain level of automation. With the future of ATC environments moving to initiatives such as the “Single European Sky” and “NextGen”, the need for automated functions such as controller to pilot data links in order to enable aircraft to fly closer together and on more direct routings, will most likely further decrease the opportunities to fly manually.

During the course of this research, on 6th July 2013, the accident occurred to the Asiana Airlines Boeing 777 in San Francisco. The aircraft crashed whilst performing a visual approach in good weather conditions. At the time of writing the NTSB has yet to publish their final report, however in June 2014 an initial press release highlighted a safety issue regarding the lack of manual flight training (NTSB, 2014).

It seems almost inconceivable that in the 21st century, one of the world's most modern airliners, fully serviceable, can crash with three qualified experienced pilots in the cockpit. Yet prior to the accident, the crew had been trained, checked and judged to be "competent" by a "system". This "systemic" failure lies at the heart of the accident, rather than just three individuals in the flight deck.

The route on to the flight deck (in Europe and some other regions) has changed considerably over the past fifteen years due to a change in the Joint Aviation Authority licensing requirements at the end of the 20th century. Traditionally, pilots would either be selected and sponsored by an airline through an approved school; or would "work their way up" via flight instruction, air taxi, regional operators and so forth until they reached a certain level of experience. Recent developments within the airline industry such as the MPL, mean that it is now possible for a pilot to start flying a highly automated aircraft from the very beginning of their flying career.

Prior to the MPL, the only option in the (civil) training system was to obtain a Commercial Pilot Licence which qualifies candidates to fly and command a "single pilot" light twin-engine aircraft, before commencing type-specific airline training. Changing the philosophy from day one of MPL training, to bring in the competency-based teamwork/multi-crew element, may be a step in the right direction for those wishing to become airline pilots. Whilst the previous system was by no means perfect, the reduction of actual flying hours in real training aircraft as part of the MPL syllabus (hours which are deemed "non-relevant" by IATA, 2011), mean trainee pilots may not develop sufficient levels of manual flying skill prior to starting the (increased) flight simulator phase of training.

With the rise of the "low cost" airlines, the main route into a modern jet airliner flight deck (in Europe) now favours low-hour "cadet" pilots, many of whom pay the cost of the training directly to the airline. These pilots may contribute a significant revenue stream to an operator, meaning those other pilots with extensive experience gained elsewhere are often overlooked for the "cheaper" option. This is not to say the training or selection of these cadet pilots is in any way inferior, far from it, competition is probably tougher than ever before. The one area in which these low-hour pilots will most likely be missing out is in the development of manual flying skills.

The military would traditionally also have provided airlines with a certain amount of experienced well-trained pilots (in terms of manual handling), yet with shrinking defence budgets and cutbacks, the pool of available ex-military pilots is smaller than ever before.

The trend in the United States has moved in the opposite direction with the introduction of the FAA's "1,500 hour" rule (FAA, 2013a), whereby a civil pilot must have a minimum of 1,500 hours flying experience and an ATP certificate in order to secure a position on the flight deck of a "part 121" scheduled air carrier. This rulemaking partly came about as a result of the 2009 accident of Colgan Air flight 3407 (NTSB, 2010) in order to address experience levels in the flight deck. Whilst both crew members had in excess of 1,500 hours at the time of the accident, it was possible then for co-pilots to start flying airline operations with 250 hours flying experience. Regional/commuter aircraft in which these pilots would typically start their careers now generally offer a level of automation comparable to much larger types. As a result some of these pilots were being placed in an operating environment at the start of their flying careers, which would limit the opportunity for them to develop manual handling skills.

A typical airline crew may use an autopilot from a height of 400 feet after take-off until shortly before landing, or after landing if an autoland is performed. The total time spent manually flying is typically in the order of one to two minutes per flight. This may result in long-haul pilots experiencing less than two hours per year of actual manual flying, with short-haul crews experiencing slightly more. With the introduction of a possible EASA "cruise pilot licence", further concerns are being raised by the European Cockpit Association, as pilots who operate solely as cruise relief pilots will have no opportunity to build up any manual flying experience.

It could be argued that today's pilots may need a greater level of basic manual flying skills than their predecessors. Also flying manually may be required in more demanding emergency situations. However, situations requiring manual flight are practiced less frequently due to the increased technology and technical reliability of current aircraft. Yet crews may still be expected to fly their aircraft without an autopilot, as an aircraft's Minimum Equipment List will specify that it is permitted to fly with such items inoperative for a certain time period.

Many operators now do little to encourage manual flight. After a series of events, one European carrier has banned the use of manual thrust on their single-aisle Airbus fleet. As a result, crews may only practice manual speed control in the simulator. Anecdotal evidence suggests that some airline crew may practice manual or raw data flight in line operation shortly prior to a proficiency check in a full flight simulator (Ebbatson, 2006). In some cases this has led to unstabilised approaches, with damage being caused to the aircraft as a result.

Whilst some pilots may wish to fly manually, their colleagues in the flight deck may feel uncomfortable with the idea, thereby preventing them from doing so. Fear of triggering a Flight Data Monitoring event, exceeding an aircraft limitation, an unstable approach/go around, and the associated appointment "without tea and biscuits" in a fleet manager's office, may mean (some) Captains become reluctant to let their First Officer manually fly the aircraft.

When these First Officers eventually become Captains, then it is highly unlikely that this behavioural pattern will change.

As pilots become “de-skilled”, has the industry now reached a critical point whereby it is actually more dangerous to have the human controlling the aircraft? Flight crew are the last line of defence and they should be able to fly their aircraft safely inside the normal flight envelope.

1.2 Rationale

The concern over declining manual flying skills is not a new issue. In the late 1990s the phrase “children of the magenta” was first used by American Airlines’ Captain Warren VanderBurgh, during a training presentation relating to automation dependency amongst flight crew. (The “magenta” referring to the colour of which automated flight path information may be shown on instrument displays). The training was aimed at changing the culture which drives pilots to attempt to operate at the highest levels of automation at all times. It stressed the need that pilots may need to revert to a lower level of automation (such as manual control) if the situation requires it, and in some cases (such as a late landing runway change) use of automation may actually increase workload.

Now over seventeen years have passed since this phrase was used, in this time those “children of the magenta” have progressed within the industry. Some may be in training positions and even be encouraging the use of automation at all times. The legacy of the “children of the magenta” is now being seen in the aftermath of several accidents. Are there now “magenta grandchildren”? It would appear so. The report into the accident of flight AF447 (BEA, 2012b, p.192) stated, “the piloting abilities of long-haul and/or ab-initio pilots were sometimes poor.” In the aftermath of the Asiana Boeing 777 crash, it was widely reported in the media that the Pilot Flying was “stressed” and “very concerned” at the prospect of having to perform a visual approach.

The following is a list of some recent incidents/accidents that have occurred to public transport category aircraft during periods of manual flight:

- Accident - Boeing 777–200ER on the 6th July 2013, crashed during a visual approach in benign conditions to Runway 28L in San Francisco (NTSB, 2014).

- Incident - Airbus A320 on 11th March 2013, approach to stall during a visual approach to Marseille, France (BEA investigation ongoing).

- Incident - Airbus A321 at Paris on 20th July 2012, speed dropped to alpha protection value during a manually flown approach (BEA, 2014).

- Incident - Airbus A320 at Tel Aviv on 3rd April 2012, approach to stall on turning final results in Alpha Floor and flaps overspeed (BEA, 2013a).

- Incident - Airbus A319 at Tunis on 24th March 2012, extreme rate of descent on glideslope intercept, GPWS alerts and descent below safe altitude (BEA, 2013b).

- Incident - Airbus A340-300 on July 22nd 2011, experienced an autopilot disconnect leading to a rapid climb of 5,000ft per minute from FL350 to FL380 and approach to an aerodynamic stall near Guadeloupe (BEA, 2012a).

- Incident - Avro RJ100 on 20th July 2011 at Nuremberg and Zurich, loss of autopilot, autothrottle and flight director. Incident report stated *"the co-pilot did not manage to continue to control the aircraft manually."* (BFU, 2012, p.8).

- Incident - B737-800NG, on 26th May 2010, whilst at FL370 the co-pilot inadvertently caused an aerodynamic "upset" causing loss of control at altitude whilst the commander had temporarily vacated the flight deck. The co-pilot was unable use manual flight to control the aircraft (DGCA, 2010).

- Accident - Airbus A330, on 12th May 2010, crashed in daylight during a go around at Tripoli in Libya (LYCAA, 2013).

- Accident - Airbus A330-203, on 1st June 2009, experienced an autopilot and autothrust disconnect due to temporary icing of the aircraft's pitot probes. The aircraft entered an aerodynamic stall following incorrect crew actions and crashed into the Atlantic Ocean (BEA, 2012b).

- Accident – Bombardier DHC 8 Q400 on 12th February 2009, crashed on approach to Buffalo Airport New York, due to a loss of control following the crew's inappropriate response to the activation of the stall warning system (NTSB, 2010).

- Accident – Boeing 737-800 on 25th February 2009, crashed on approach to Amsterdam Airport due to loss of control and stall following the crew's inappropriate monitoring of airspeed (Dekker, 2010).

- Accident - On 27th November 2008 Airbus A320 Loss of control following aerodynamic stall, aircraft impacted ocean near Perpignan, France (BEA, 2010).

These accidents and incidents occurred to aircraft which had no significant airworthiness defects or any performance limitations. A common factor in all but two of these occurrences, is that they featured low airspeeds and high angles of attack, which the crew either did not monitor or were unaware of, followed by incorrect manual flying skills. Further understanding is required as to what is preventing pilots from being able to practice manual flight, so that accidents such as these may be preventable.

1.3 Aims and objectives

There are many subjective concerns regarding pilots degraded manual flying skills, as evident from the outcome of several accidents. There is however a dearth of objective data with which to support these concerns. The aims are to add credence and quantifiable evidence to these concerns.

The main objectives of this study are as follows:

- To establish pilots' own perceptions to the importance of manual flying skills (and monitoring), as well as their awareness and susceptibility to any degradation of them. The findings will be compared to relevant parts of previous studies.

- To investigate which human factors related issues may lead to flight crews' reluctance to practice manual flying skills.

- To establish the amount of manual flying carried out by crews in normal line operations, and to identify any situations and frequency where manual flight has been required, such as aircraft equipment or automation failure.

- To investigate any possible differences between groups of pilots regarding the amount manual flying they perform. For example, differences between age groups, region, type of operation and initial flying training background.

- To establish any methods pilots use to maintain their manual flying proficiency.

- To ascertain the effect of different automation policies of operators.

- To ascertain pilots' views of whether current training for manual flight is sufficient.

- To ascertain pilots' views on current aircraft design issues with systems relating to manual flight associated with low speed and high angle of attack situations.

There are no experimental hypotheses as such, as the study is of an exploratory nature and related to pilots' perceptions. However, it is expected that several key themes will become apparent.

Chapter 2 Literature Review

Given the importance of manual flying skills, there have been remarkably few studies solely investigating the degradation of them. The vast majority of published work relates to how manual flying skills have declined as a by-product of flightdeck automation issues. Subsequently, there is little literature detailing *why* pilots may be reluctant, or unable to practice their skills.

2.1 Measuring and assessing manual flying performance.

Gillen (2008) conducted a study using a group of 30 pilots to assess their performance in basic instrument flying skills in manual flight. The group was divided into two groups based on their type of operational flying, long-haul aircraft and short-haul aircraft. Each pilot was graded by a check airman (examiner) according to FAA ATP proficiency standards. Initially a qualitative survey was conducted to assess the pilots' own views of their instrument flying ability.

The results from the study highlighted the issue that pilots are experiencing a decline in their basic instrument flying ability. This is backed up by the fact that 80% of those pilots surveyed agreed that their manual flying skills had declined over time. Of note is that from the qualitative survey, 100% of the pilot group said they could fly basic "raw data" manoeuvres. 60% indicated they felt "comfortable" flying raw data and 80% stated they often practiced raw data flying. The results from the simulator showed that the pilots' performance was "significantly below" the acceptable standard required by the FAA for Airline Transport Pilots and nearer to a "basic" level. There was no discernible difference in the performance between the two groups.

Ebbatson (2009) conducted a significant amount of research into *"the loss of flying skills in pilots of highly automated airliners".* The research focused on three main areas. These were: the cognitive aspects of manual flight, evaluation and selection of a method of measuring manual flying performance, and evaluating manual flying performance against a pilot's amount of exposure to automation.

In this research a Boeing 737 full flight simulator was used to assess a sample group of66 current Boeing 737 pilots in a manual flying task. All the pilots were from the same operator in the United Kingdom and the pilot group was assessed at the end of their annual LPC simulator session. The pilots will all have had a certain competency level since they had all recently passed the LPC, so the nature of preparation and recency in the simulator environment may have increased their performance beyond what would be expected in normal line operations. Each pilot was assessed by a TRE on their performance to hand fly a "raw data" ILS approach (without the use of flight director guidance or autoflight systems) and a go around manoeuvre. The number two (right) engine had been simulated as having failed, so this increased the manual control requirements to a greater level when compared to Gillen's study. A second TRE was present during a random number of simulator sessions and their assessment of the pilots' performance was used to provide a level of "inter-rater reliability" of the rating scale. The two TREs were statistically proven to be in "almost total agreement" when it came to assessing the pilots' manual flying skills. The Likert scale used to assess the pilots' manual handling ability was based on the operator's own rating scale for training their own TREs. 78% of the pilots demonstrated "desirable" manual flying skills and the remaining 22% were classified as having weaker but "tolerable" manual flying skills. Yet in the discussion of the results, Ebbatson stated that a significant proportion of the pilots' performance was "very low" and was at the "limits of acceptability" (it did not clearly quantify what this significant proportion was). It is possible that a number of pilots may have used the aircraft for manual flying "practice" in the run up to their LPC.

The actual manual flying task required in Ebbatson's research (a single engine, raw data ILS approach), is one which would very seldom be faced by a crew in line operations. In fact, regulatory training and testing requirements at the time (CAA, 2010) only required a raw data ILS to be flown with both engines operative, and a single engine approach may use the flight director. Nevertheless, the task should reasonably expected to be within the skill set of any commercial pilot.

The results showed that there was no correlation between the number of flying hours the pilot had experienced and their performance. It was noted that the pilots who had flown more manual approaches in the preceding week performed better and "recency" of manual flying seemed to be more prevalent than long-term -but "not recent"- flying experience. A survey of the pilots revealed that 77% felt that their manual flying skills had deteriorated, 16 % indicated no change and 7% felt that their skills had improved.

A study conducted in Germany (Haslbeck et al., 2012) proposed an experimental methodology to measure the manual flying skills of pilots under certain performance shaping factors, such as training, recency or fatigue, whilst carrying out a manual flying task. It was similar in respect to Gillen's and Ebbatson's research in that the manual flying task was to be a manually hand flown ILS, however it differed in that the participants were not aware of the requirement until a failure of the aircraft's flight guidance system following a previous missed approach. The study also proposed to makes use of an eye tracking system to record visual behaviour and the pilots' scanning of the cockpit.

In the study *"Differences in Aircrew Manual Skills in Automated and Conventional Flight decks"* (Veillette/NASA, 1997), it mentions that 56% of all "non-fatal, pilot-caused" accidents were related to "defective perceptual motor activities." The study also highlights an analysis of accidents that occurred to United States Air Force aircraft during training. It was noted that there was a spike in accident rates immediately following pilots' leave periods. They concluded that piloting skills must be practiced regularly to maintain proficiency. The study used a group of twenty four crews; twelve crews from an “automated” aircraft type and twelve from a “conventional” type. It was stated that the two aircraft types were “virtually equal” except for the degree of automation in the flight deck. Each crew, as part of their recurrent simulator training, was required to carry out a number of standard manoeuvres. Selected parameters, including pilot inputs and aircraft deviations were recorded from the flight simulator by a software algorithm.

Analysis of the results showed a “significant difference” between the two groups’ manual flying performance. The group flying the “automated” aircraft consistently exhibited a greater number of deviations from the assigned courses and airspeeds and also from nominal pitch and bank attitudes, when they were compared to the “conventional” group. Also a greater variance of performance within the pilots of the “automated” group was highlighted, which may be due to variables such as a pilot’s total flying time and experience of previous aircraft types. The study recommends in the short term, that airline crews should fly “a judicious balance” of automated and manually flown departures and arrivals, in order to maintain manual flying skills and optimise safety. The authors of the study say they are “not convinced” that the difference in performance between the groups is solely due to a lack of practice from the “automated” group. Therefore their recommendation may only address the symptom instead of the underlying cause.

A study investigating “the impact of glass cockpit experience on manual flight skills” (Young et al., 2006), assessed 110 experienced pilots from a variety of civil and military trained backgrounds in a flight training device representative of a transport category aircraft equipped with “round dial” (analogue) instrumentation. Their findings suggested that flight crews of “glass cockpit” aircraft who made more use of automated (flight control) modes had reduced manual flying skills and a less effective instrument crosscheck (scan). The study also showed an expected relationship between the pilots’ total flight time and ability to “maintain flight within practical test standards”. A relationship between the smoothness of manual flight control inputs and the amount of raw data flying experience was also suggested, in that those with more “raw data” experience made smoother inputs.

A more recent study (Casner et al., 2014) tested a group of sixteen Boeing 747 pilots in a flight simulator whilst looking at flight instrument scanning during manual control. Problems with pilots’ cognitive skills, navigation, situational awareness and their ability to recognise instrument system failures, were more frequently observed whilst they were flying manually. Their findings suggested that pilots’ “raw data” flying skills would benefit from practice, and also that manually flying whilst following flight director commands will probably not keep instrument scanning skills “sharp.”

2.2 Previous aircrew surveys

Numerous surveys have been carried out to establish pilots' perceptions towards automation.

Curry (1985) conducted a human factors study into "The Introduction of New Cockpit Technology." This involved a survey of a group of 102 pilots from three different airlines who all flew the Boeing 767, which had been in service for a relatively short period of time. Whilst it focused mainly on automation and design issues, pilots were asked how much hand-flying they like to do and if they thought their flying skills would suffer with the use of too much automation.

A similar study was conducted by Wiener (1989) which investigated a group of Boeing 757 pilots. It was established that nearly half of the pilots were concerned about a possible loss of flying skills with too much automation.

The Advanced Technology Aircraft Safety Survey Report conducted in Australia (BASI, 1998) followed very similar lines to Curry and Wiener's studies, but went into slightly greater detail by investigating if pilots thought there had been a decline in their manual flying skills.

Rudisill's (1995) automation study indicated that pilots of automated aircraft had reported less confidence in their manual handling abilities and a loss of their instrument scan. Pilots stated that a greater amount of self-discipline was required in order to turn off the automation and practice manual flying. The pilots also stated that "manual flying should be encouraged by management" and use of "automation should not become mandated". The group of older pilots in the study recognised that younger pilots were able to adapt to automation faster, but their lack of exposure to "conventional" aircraft left them with little knowledge to fall back on in the event the automation failed.

ECOTTRIS (1998) conducted research involving pilots transitioning to glass cockpit aircraft and used data from 152 pilot completed questionnaires to determine areas by "skill group" related to "importance" and "need/priority for extra training". Of these groups manual flying ranked third and fourth respectively. Knowledge of automation, decision making and Crew Resource Management, ranked above. With regards to their basic flying skills, most of the pilots revealed they felt "totally comfortable" or "very comfortable" with their capabilities; and those that felt less than comfortable cited that their company's operating philosophy reduced their exposure to manual flying. The study does not quantify the proportion of pilots and the term "basic flying skills" is not clear whether it refers to manual flight without any automation, such as without a Flight Director system (raw data), or simply hand flying but following a flight director. Interestingly though, it states "dangerously low levels of manual flying skills" may be revealed due to events such as TCAS or GPWS recovery. The study also states that handling skills will "probably be at a high level" for pilots that have just undergone transition training onto a glass cockpit/automated type aircraft and these skills will degrade if manual flying under line operations is limited. Some 57% of the surveyed pilots indicated that they thought further training is required in this area. The surveyed pilots that had greater on-type experience (in automated aircraft) rated the need for manual flying training as being “significantly greater”, than those with less on-type experience.

A more recent study (Mitchell et al., 2009) used a qualitative analysis of 262 pilots’ perceptions of flight deck automation. Many positive comments were recorded; however it found concerns amongst pilots regarding lost skills. It also highlighted that it is possible for “automation to mask a lack of situational awareness” in younger “less skilled” pilots. On the subject of stress and workload, concerns were raised that when the automation failed, inexperienced pilots had difficulty coping with the increased workload. Complacency and over reliance on automation were also noted.

2.3 The regulatory perspective

The issue of degraded manual flying skills in airline crew is now becoming widely acknowledged by the key aviation safety regulators and aviation associations.

In Europe, a survey into the effects of cockpit automation was conducted by EASA (2012a). The development of the EASA Automation Policy, of which this survey played a key part, mentions:

“the new generation of pilots may lack basic flying skills when the automation disconnects or fails or when there is a need to revert to a lower automation level, including hand flying the aircraft” (EASA, 2013a, p.1).

The number of participants in the survey was 151, of these almost 75% were from European organisations, 13% from North American and the remaining 12% distributed evenly throughout the rest of the world (EASA, 2012b). This distribution is hardly surprising given that EASA is a European agency. Some 72% of the respondents were from the pilot or training community. The most agreed point relating to automation issues was:

“Basic manual and cognitive flying skills tend to decline because of lack of practice and feel for the aircraft can deteriorate” (EASA, 2013a, p.8).

The top level and most agreed result from the respondents regarding ‘consensual improvement paths’ was that basic airmanship and pilots’ manual flying skills needed to be improved (EASA, 2013a, p.9), but no definition of airmanship was provided.

Whilst the EASA research relates to automation, there is no mention of older (senior) generation pilots lacking flying skill, only that they may be “less comfortable” with automation (EASA, 2013a, p.1). Bearing in mind that aircraft such as the Airbus A320 have now been in service for over 25 years, the

Boeing 737NG for over 17 years, Boeing 777 for 19 years , 747-400 for 25 years and 757/767 for over 30 years, very few of the current senior pilots will not have had any significant exposure to automated aircraft throughout their careers to date.

EASA issued a Safety Information Bulletin on 23rd April 2013, specifically relating to “Manual Flight Training and Operations” (EASA, 2013b). The recommendations which they publish are also stated to be non-mandatory. So the effectiveness of the implementation of these recommendations will most likely be limited. In today’s airline environment where every penny is controlled, it is a very rare airline/operator indeed that will invest in something that is not mandated.

At the time of writing, EASA does not appear to be actively pursuing the issue of manual flying skill any further. It is however developing a rule making on “Loss of Control Prevention and Recovery Training” via RMT 0581 and 0582, which is currently in progress (EASA, 2013c).

In January 2013, the FAA issued a safety alert regarding manual handling (SAFO 13002). This alert generated considerable media awareness. They state:

“continuous use of those (autoflight) systems does not reinforce a pilot’s knowledge and skills in manual flight operations. …*continuous use of autoflight systems could lead to degradation of the pilot’s ability to quickly recover the aircraft from an undesired state.”* (FAA, 2013c).

“maintaining and improving the knowledge and skills for manual flight operations is necessary for safe flight operations.” (FAA, 2013c).

This alert identified an increase in manual handling errors, but the amount of increase is not quantified, nor was the time scale involved. It could be argued that a number of errors are to be expected in manual flight operations, due to the nature of the human element and the susceptibility of the human to err.

When compared to the FAA’s SAFO, the Safety Information Bulletin issued by EASA is noteworthy due to its inclusion of certain measures to control the risk of increased manual flight operations. It encourages the use of Safety Management Systems, Flight Data Monitoring and ATQP to monitor the possible “drawbacks” of increased manual flying.

The FAA’s Performance-based operation Aviation Rulemaking Committee and Commercial Aviation Safety Team highlighted vulnerable areas regarding manual flying in their report *“Operational Use of Flight Path Management Systems”* (FAA, 2013b). During the creation of the report a comprehensive list of accidents were studied from a variety of sources. The working group identified 60% of the 26 accidents studied having a manual handling error as a contributory factor. A total of 28 different findings were presented, of which the second related to manual flying:

“Finding 2 - Manual Flight Operations.

Vulnerabilities were identified in pilot knowledge and skills for manual flight operations, including:

- *Prevention, recognition and recovery from upset conditions, stalls or unusual attitudes,*
- *Appropriate manual handling after transition from automated control,*
- *Inadequate energy management,*
- *Inappropriate control inputs for the situation,*
- *Crew coordination, especially relating to aircraft control, and*
- *Definition, development, and retention of such skills.”* (FAA, 2013b, p.2).

Out of the eighteen recommendations from the report, the top level recommendation was:

“Develop and implement standards and guidance for maintaining and improving knowledge and skills for manual flight operations” (FAA, 2013b, p.6).

In 2004, the United Kingdom CAA paper on the “Reliance of Flight Crew on Automation” stated:

“*There has been very little research published on the subject of the change in manual flying skill …. it is reported consistently that there is a discernible reduction in manual flying skills that is correlated with the use of automation.”* (CAA, 2004, ch. 4, p. 3).

Subsequently, research was conducted on behalf of the CAA’s Safety Regulation Group to examine a revised training syllabus which would allow pilots to be better trained in the use of automation (Wood and Huddlestone, 2006). It proposed that the procedural knowledge required to manually control an aircraft is introduced at an earlier stage during type rating training. This would associate it with previously learned manual skills, rather than leaving it until the end of training when manual flying is introduced as a result of failures leading to a loss of automated systems.

The CAA’s “Significant Seven” (CAA, 2011) are the seven highest safety risks that were identified following analysis of occurrences and aircraft accidents. “Loss of control”, is one of the top seven risks. Currently a data set of standardised FDM events is being developed to monitor the precursors to a loss of control in flight.

2.4 The manufacturers' perspective

With the upcoming introduction of the A350 into service, Airbus the manufacturer of arguably the world's most automated aircraft families, are now "re-focusing on basic handling" philosophies from the beginning of training, as mentioned at the RAeS Flight Crew Training Conference 2012, "The Future Flight Deck and Role of the Pilot" by Captain David Owens. In their Standard Operating Procedures (Flight Operations Briefing Notes) publication, titled "Optimum Use of Automation", Airbus recognises and state that:

"Reversion to hand flying and manual thrust control actually may be the correct level of automation, depending on the prevailing conditions" (Airbus, 2006).

A senior training manager from Airbus recently highlighted that the importance of manual flying skills has been reduced when compared to the past, but that "basic handling skills are still essential for safe operations" (Drappier, 2012).

Boeing also includes a brief statement in their training literature for some of their more automated aircraft types such as the Boeing 777 and 787:

"Autothrottle use is recommended during all phases of flight, when in manual flight, autothrottle use is also recommended, however manual thrust may be used to maintain pilot proficiency" (Boeing 787 FCTM, 2010).

2.5 Skill fade

The skills required to manually fly an aircraft to IFR tolerances are susceptible to decay. Research carried out by Mengelkoch (1971) addressed "the forgetting of instrument flying skills". Childs, et al. (1983) investigated pilots' skill retention at various time intervals (8, 16 and 24 months) following training. Wright (1973) found that some 90% of (army) pilots lose IFR flying ability within 12 months of either no or minimum practice. Extended periods of more than 12 months of non-practice, showed practically no difference in the amount of refresher re-training required to reach the required standard.

A significant literature review on skill fade was conducted in 2007 on behalf of the Human Factors Integration Defence Technology Centre in the United Kingdom (Leonard, 2007). It included reference to Arthur et al. (1998), which indicates that there are substantial losses of skills with non-practice. It found that physical skills were less susceptible to decline than accuracy-based and cognitive ones. Given that manual flight requires a combination of these skills, it supports previous studies regarding loss of flying ability.

Research into retention of Airline Pilots' skills was carried out by Hendrickson et al. (2006). It was found that when airline crews were evaluated in normal and emergency flying manoeuvres at twelve month intervals, they showed significantly higher skill decay when compared to a group evaluated at six month intervals. It also showed that when manoeuvres had been “pre-briefed,” less skill decay was observed than compared to “non-briefed” ones, due to pilots’ being able to mentally rehearse manoeuvres beforehand. It suggested that mental rehearsal whilst flying in normal operations may mitigate skill decay.

2.6 Complacency and vigilance

One potential negative aspect of automation is that it may cause some aircrew to become complacent. Using highly automated equipment on a regular basis, which is deemed as being reliable, may lead pilots into thinking that their manual flying skills are unlikely to be required.

Parasuraman et al. (1993) provided the first “empirical” evidence regarding human performance as a result of automation-induced complacency. It was found that the subjects’ monitoring of automation was accurate when given a single task, but poor when given multiple tasks such as monitoring whilst carrying out a manual tracking task. It highlights that many monitoring failures occur when pilots are in multi-task situations. It was also found that levels of trust were positively correlated with increased automation usage (Riley (1994), cited in Parasuraman et al., 1993, p.28).

Bailey and Scerbo’s (2005) research relating to monitoring from a vigilance perspective found contrasting results to Parasuraman et al., in that when subjects were given a manual flying task with three additional monitoring tasks, the level of monitoring remained more constant but there was a degraded level of manual flying performance. It was suggested that there was a strategic adjustment, or trade off in the amount of mental resources/effort used by the subjects in order to maintain their monitoring tasks, and that the subjects had adopted “non-optimal strategies” for the operation of the primary manual flying task. Their findings also indicated that a task requiring sustained attention (such as manual flying) is “inherently stressful” and in order for the subjects to reduce stress and maintain a level of performance, then compensatory strategies must be adopted.

Prinzell (2002) investigated self-efficacy of monitoring and vigilance performance. The results suggested low levels of self-efficacy (self-confidence) may increase an individual’s potential to reach a state of automation-induced complacency; whereas high levels may produce over confidence that may limit strategies for managing cognitive workload.

2.7 Fatigue

Many aspects of human performance will be affected by fatigue, such as attention and awareness, which may affect the final phases of a flight (Lyman and Orlady, 1981). The effects of fatigue on manual flying ability will no doubt be significant, as no pilot group is exempt from fatigue. Bourgeois-Buogrine et al. (2003) found acute fatigue to be present in long and short-haul pilot groups due to work schedules, with causal factors appearing in numerous incident and accident investigations. Jackson and Earl (2006) found that 75% of short-haul pilots had reported severe fatigue. Short-haul pilots' fatigue levels were primarily influenced by the number of sectors flown and length of duty period, rather than the time of day (Powell et al., 2007).

The effects of fatigue on Corporate/Executive pilots were also studied (Rosekind et al., 2000) as private operators may not be required to operate under regulatory flight time limitations. These pilots may be subject to long periods of being "available," with rapidly changing schedules and multiple time zone changes. Combined with extended duty periods, possibly including other significant activities such as catering and cleaning of their aircraft, this may increase the risk of fatigue.

2.8 Training

Ebbatson (2006) highlights several accidents that were caused in part by flight crews practicing manual flight prior to their proficiency checks in a flight simulator.

In today's airline operating environment where expenditure is tightly managed, training budgets are "lean". Such accidents may be expected if pilots are using the aircraft to become proficient in manual flying prior to a simulator check, on which their livelihood and career may depend on a successful outcome. Some major airlines do however schedule their crews for a dedicated manual flight training session in a full flight simulator once per year, but these airlines are presently in the vast minority.

Chapter 3 Methodology

3.1 Introduction

The main aims of this research were linked to ascertaining pilots' perceptions regarding the degradation of manual flying skills and are detailed in section 1.3.

The target population was flight crew of public transport category fixed wing aircraft equipped with a certain level of automation, this being at least one FMS, autopilot and flight director system.

The use of a survey or questionnaire was thought to be the most suitable method, in that it would allow the largest number of participants to be reached in the time frame available. For the intended number of pilots, personal interviews would be impractical due to the logistics involved. The survey permits quantitative and qualitative data collection methods to be used in order to obtain the data for analysis.

The survey software package used was created by Qualtrics. This package enabled a variety of question types to be created and recorded. For those questions involving multiple choice answers, a Likert scale (Likert, 1932) was used in order to be able to rate statements involving respondents' responses to particular questions. The number of Likert items could be changed depending on the question. A typical five level Likert item could be shown as:

1. Strongly agree
2. Agree
3. Neutral
4. Disagree
5. Strongly disagree

A weighting of between one and five was assigned to each answer. As statements could have a positive as well as negative aspect, a "1" value would indicate strong agreement. For some questions a *"not applicable to my aircraft type"* response was also available. These responses could be filtered by the Qualtrics software during the analysis stage. This method permits data to be easily displayed in graphical forms such as a frequency histogram and allows further statistical analysis where necessary.

Regarding ethical research, approval was sought from Cranfield University's Science and Engineering Research Ethics Committee (SEREC*)* in order to be able to undertake the survey. It was made sure that no questions would investigate or identify rule breaking behaviour or violations.

3.2 Survey structure and content

The framework of the survey was built around five main sections:

- Section 1 Demographics/Flying background
- Section 2 Manual flight requirements
- Section 3 Training requirements
- Section 4 Workload and performance
- Section 5 Monitoring and display design

A copy of the full survey may be seen in Appendix B.

In order to provide an element of inter-reliability, certain questions were deliberately made similar but placed in different sections. Also several questions related to the same issue (such as fatigue), but asked pilots if they had noticed their colleagues' behaviour and then further on they were asked about their own behaviour. Some of the similar questions had the Likert type responses in the reverse order to ensure the answers were read.

A pilot's self-assessment/perception of their own flying skills would be very difficult to measure or quantify due to every one being an individual. Also there may be the intrinsic aspect of human nature, that it is difficult to objectively assess one's own performance or admit shortcomings. It may be more objective for them to assess the skills of others. However, each assessment is still likely to have some subjectivity. One individual's performance may be judged differently by others. It must be stressed that these are pilots' opinions and not necessarily scientific hard facts. Nevertheless, the purpose is to be able to provide a trend of pilot behaviour.

A more objective view of pilots' performance may be available from a group of Training/Check Captains/Examiners, as they should be able to (by definition) check and examine to a set of regulated standards and guidelines.

Given that the survey was quite lengthy, in order to reduce the amount of time required for each respondent, it was decided to collect demographic data (age, flying hours etc.) by selecting from a range rather than inputting an exact value. Participant anonymity is further enhanced without an exact age or number of flying hours. Each range maybe an indicator of where a pilot is within the population, for example between 200 and 1,500 hours the pilot will not yet have an ATPL and will likely be nearer to the start of their flying career. There is the well-known adage of "hours does not equal experience" (Ebbatson 2009), neither does it correlate to ability.

It was decided not to include the participant's gender, as it should have no effect on manual flying ability.

To provide a measure of validity for this survey, four questions were based on previous surveys. These being: Curry (1985), Wiener (1989), BASI (1998) and

EASA (2012a). This was done in order to be able to compare results and also to provide a further indication of the reliability of the current study. The questions incorporated into this survey from the other studies are shown below:

- *“Improve basic airmanship and manual flying skills of pilots”* (EASA 2012, Question 4.1, p. 9).

- *“My manual flying skills have declined since I started flying advanced technology aircraft”* (BASI, 1998, p. 30).

- *“I am concerned about a possible loss of my flying skills with too much automation”* (Curry, 1985, p. 64; Wiener, 1989, p. 81).

- *“I like to hand fly part of every flight to keep my skills up”* (Curry, 1985, p. 62; BASI, 1998, p.29; Wiener,1989, p. 81).

After several loss of control accidents (such as AF447 and the Colgan Air Q400), it was decided to see how many pilots had received upset recovery simulator training in the last 36 months in order to gauge the effectiveness of the training “system” in the aftermath of these accidents.

The main factors which may dissuade pilots from flying manually were investigated. The responses were initially grounded from the author’s own previous experience of replies from colleagues, when asked after landing, why they did not practice manual flight in low workload situations.

- “I was tired.”
- “I did not want to overload the other pilot.”
- “It’s safer.”
- “It gives me more extra mental capacity.”
- “I couldn’t be bothered.”
- “I’m too lazy.”
- “It is company procedure, everyone does it that way.”
- “There was a lot of traffic.”
- “Flying straight is easy.”

The study by Ebbatson et al. (2010), involving recency in manual flying tasks, provided the impetus to investigate pilots’ perceptions on recency versus basic training. This may be seen as question 3.11 in the survey.

The opportunity for respondents to provide extra comments in free text boxes was also used in three questions. These related to situations where manual flight was required, either due to aircraft systems failure or other external factors. The final free text box in the survey enabled each respondent to add any extra comments about the survey or the subject of manual flying.

3.3 Survey distribution

The survey was distributed to pilots who have an ATPL or CPL with type rating on a multi-pilot aircraft. Each pilot was able to access the online survey via an internet based web-link. The first part of the survey explained the background and why they were being asked to participate. Each participant's consent and right to withdraw was also made clear.

In order to obtain the largest and most suitable target population, many of the worldwide Pilot Associations (Airline and Business Aviation) were contacted with the rationale for the research and the request to distribute the online link to the survey to their pilot members.

It was felt that by using these associations, this would ensure that the respondents were actually qualified and suitable to participate. Had the survey been directly distributed via more open means, such as social media (e.g. LinkedIn) or internet aviation forums open to the public (e.g. Pprune), this may have allowed "unqualified" persons to participate which could have diluted the data.

The survey also was not sent directly to any particular airline or operator. This was in part to preserve anonymity, and also to try and avoid any bias or possible skewing of the results. The intent being to obtain a balanced overview from pilots worldwide.

3.4 Data treatment

Survey data obtained through the Qualtrics software was able to be processed, filtered and analysed via the "reports" function. Statistical data such as mean, standard deviation and variances was available for each question involving quantitative data. The software was also capable of producing graphical and tabular outputs. Many of these outputs were used directly and others were edited in Excel for clarity.

The gathered data was analysed as a whole, then divided into sub-groups for further analysis and comparison between sub-groups. The group comparisons were as follows:

- Age group (ages 18-35 and 46-65).
- Type of operation (long-haul, short-haul).
- Initial flying training background (civil or military).
- Pilot function (Captain or First Officer).
- Flying hours (high hours or low hours).
- Region.

The corporate/business aviation group of pilots was also analysed independently.

An analysis of the group of Training Captains/Examiners was also performed separately, as to provide some measure of objective analysis for some questions.

Analysis of the MPL trained pilots was also carried out. However due to the relatively small sample size, the results are included for information purposes only.

Where differences were apparent between groups, statistical tests were performed using the Excel or Social Statistics software to check the significance of results in relation to the research objectives.

Sufficient data was also available to compare responses grouped by aircraft type:

- Medium jet transport: Airbus A320 series against Boeing 737 series
- Large jet transport: Airbus A330 against Boeing 777

The qualitative “free text” data was exported to an Excel spreadsheet then further to Microsoft Word for editing in order to remove any non-pertinent comments. A thematic analysis using a “quasi-statistical approach” (Robson, 2011) was then used to process this qualitative data. This used frequency of certain words or phrases to determine the main themes and their relative importance.

Chapter 4 Results

Data was gathered between the 7th April and the 31st July 2014. A total of 1,059 surveys were started, 884 were completed successfully and provided useful data. Of these, one was discarded due to highly erroneous category responses. 175 surveys were incomplete and deleted. Therefore 883 completed responses were available for analysis.

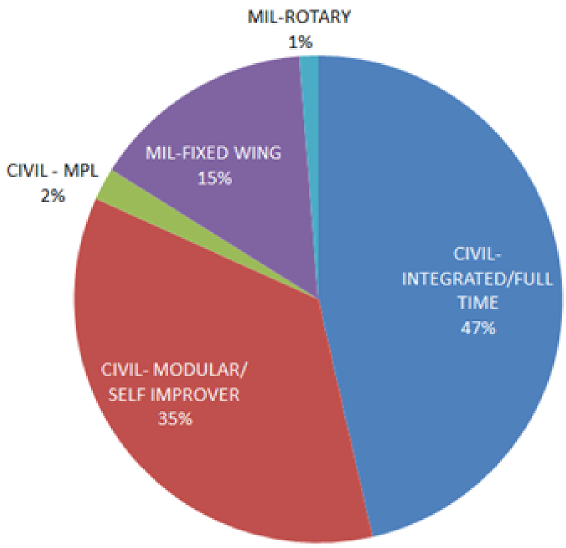
Results were rounded to the nearest 1% by the Qualtrics software. Where a specific question from the survey is indicated, it is referred to by number in parentheses (e.g. Q2.1). The full survey questions may be seen in Appendix B.

4.1 Demographic data of survey population

This section recorded the demographic data of the pilots. The following results are for the whole population. Comparisons showing relevant differences between groups with regards to the amount of manual flying performed are detailed in section 4.8.

4.1.1 Initial flying training background

Figure 4.1 Respondents' initial flying training background



741 (84%) pilots were from a civilian flying training background. Of these 410 (47%) were Integrated/Full Time, 312 (35%) were Modular/Self Improver and 19 (2%) were MPL trained.

142 (16%) pilots were from a military flying training background, with 131 (15%) having undergone fixed wing training and 11 (1%) respondents were from a rotary wing (helicopter) background before transferring to fixed wing civil flying.

4.1.2 Number of flying hours

Table 4.1 Distribution of respondents' flying hours

#	Answer		Response	%
1	200 to 1,500		56	6%
2	1,500 to 3,000		91	10%
3	3,000 to 5,000		102	12%
4	5,000 to 10,000		243	28%
5	10,001 to 15,000		197	22%
6	15,000 +		194	22%
	Total		883	100%

The mean value was in the 5,000 to 10,000 hours range.

4.1.3 Age range

The results showed a fairly even distribution across the age range brackets, with the exception of the low number or respondents in the age 18- 25 range. This is not surprising given that pilots of this age may be still undergoing their basic training or having completed training, seeking their first commercial flying position.

Table 4.2 Distribution of respondents' ages

#	Answer		Response	%
1	18 to 25		48	5%
2	26 to 35		225	25%
3	36 to 45		257	29%
4	46 to 55		212	24%
5	56 to 65		137	16%
6	I would rather not say		4	0%
	Total		883	100%

One respondent commented that there was no "over 65" category. The current limit for piloting commercial public transport operations is 65, so that is why there was no >65 years old category. It is acknowledged that there are pilots who are more than 65 years old engaged in other forms of "aerial work".

4.1.4 Aircraft types

Table 4.3 Number of respondents per aircraft type

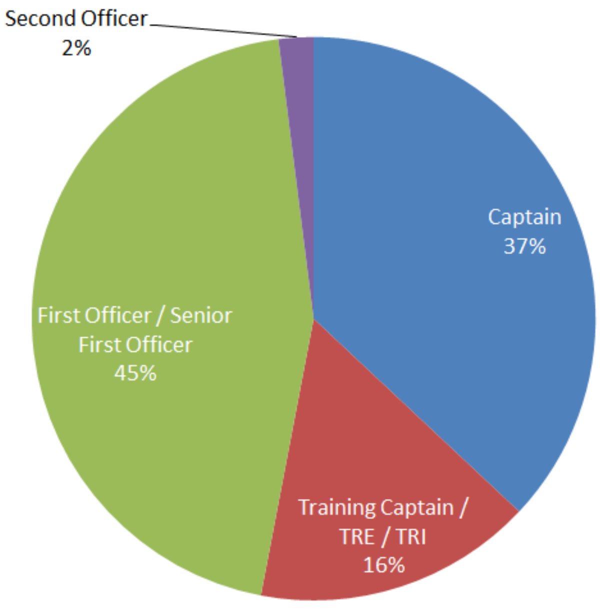
#	Answer		Response	%
1	Airbus A300 / 310		1	0%
2	Airbus A318 / 319 / 320 / 321		160	18%
3	Airbus A330		126	14%
4	Airbus A340		49	6%
5	Airbus A380		3	0%
6	Boeing 717		6	1%
7	Boeing 737 - 300 to 900 / BBJ		116	13%
8	Boeing 747 - 400 / 747-8		89	10%
9	Boeing 757		8	1%
10	Boeing 767		18	2%
11	Boeing 777		122	14%
12	Boeing 787		3	0%
13	MD 80 series / DC-9		4	0%
14	MD11/10 (DC-10)		1	0%
15	MD90		1	0%
16	Embraer 135 / 140 / 145		2	0%
17	Embraer 170 / 175 / 190 / 195 / Lineage		20	2%
18	Embraer 120		0	0%
19	DHC 8 Q400		14	2%
20	DHC 8 100/200/300		10	1%
21	Bombardier Learjet series		1	0%
22	Bombardier Global Series		2	0%
23	Bombardier Challenger series		6	1%
24	Bombardier CRJ 100-900		5	1%
25	SAAB 340		2	0%
26	SAAB 2000		4	0%
27	Dornier 328TP/328J		10	1%
28	ATR 42/72 series 200/300/500/600		24	3%
29	BAe Jetstream 41		1	0%
30	BAe 146/AVRO RJ		6	1%
31	BAe ATP		2	0%
32	Fokker 50		0	0%
33	Fokker 70/100		0	0%
34	Gulfstream GIV/450/V/550/650		9	1%
35	Gulfstream G150/200/280		1	0%
36	Dassault Falcon 50/2000/900/7X		19	2%
37	Beechcraft Kingair series		3	0%
38	Hawker HS125/800		4	0%
39	Cessna Citation Series		7	1%
40	Lockheed Tri-Star		1	0%
41	Other type - not listed		23	3%
	Total		883	100%

The respondents flew a total of 38 different aircraft types. The most prevalent aircraft types were as follows:

- Airbus A318/319/320/321 18%
- Airbus A330 14%
- Boeing 777 14%
- Boeing 737 300-900 13%
- Boeing 747-400/747-8 10%
- Airbus A340 6%

4.1.5 Pilot function

Figure 4.2 Distribution by pilot function.



469 pilots (53%) of the respondents were Captains, of these 143 (16%) were Training Captain/Instructor/TRI/SFI or TRE/SFE. The remaining 393 (45%) were First Officers and 21 (2%) were Second Officers (Cruise Relief Pilots).

4.1.6 Region

The distribution of respondents by region can be seen in table 4.4:

Table 4.4 Distribution of respondents by region

#	Answer		Response	%
1	UK / Ireland		97	11%
2	Western Europe		280	32%
3	Eastern Europe		35	4%
4	Middle East		72	8%
5	Asia		202	23%
6	Africa		7	1%
7	North America (USA / CANADA)		105	12%
8	South America		54	6%
9	Australia / New Zealand		31	4%
	Total		883	100%

4.1.7 Type of operation

Table 4.5 Distribution of respondents by type of operation

#	Answer		Response	%
1	Regional / Short haul		457	52%
2	Mid-haul		439	50%
3	Long haul		376	43%
4	Corporate / Business Aviation		71	8%
5	Cargo / Air Freight		90	10%

Pilots may be involved in a mix of long and medium/short haul operations depending on their operator. It was possible for pilots to select more than one type of operation.

4.2 Manual flying related issues

This section looked at situations where manual flight is required due to various factors beyond the control of the crew.

4.2.1 Guidance on maintaining flying skills

- 98% of the surveyed pilots were in agreement that good manual flying skills are essential for any commercial pilot (Q2.1).

- 54% of pilots have received from their operator a specific guidance with regards to maintaining manual flying skills (Q2.3).

- 14% had received from their regulatory authority (e.g. CAA/FAA/DGAC) some specific guidance with regards to maintaining manual flying skills (Q2.4).

4.2.2 Situations requiring manual flight due to system / equipment failure

- 657 pilots (74%) have been faced with failure of a flight guidance system or autopilot in flight (Q2.2).

- 82% of pilots had found at some point, their aircraft to be in an automated mode which they were not expecting and then resolved the situation by reverting to manual flight (Q4.2).

- 642 pilots (73%) have been faced with an in-flight aircraft system or equipment failure that required them to fly the aircraft manually (Q2.5).

This area was further examined which investigated the type of system or equipment failures that had been experienced.

623 (71%) pilots provided free text responses, containing a description of the failures that were experienced. The responses consisted of 9,048 words. Each response was individually analysed and the types of failure were identified, grouped by theme and quantified as seen in table 4.6.

Each event is categorized as having occurred per respondent. If a pilot experienced the same event type multiple times only one entry was made. Pilots may have experienced multiple different event types which were entered separately.

Table 4.6 Type of aircraft system or equipment failure that required manual flight

Type of event.	Number of respondents per event.	Percentage as total of pilot population. (n=883)
Autopilot failed or inoperative.	407	46%
Other avionics system failure (including loss of ADIRU/AHRS/INS/FCC/Stall warning / PFD/ND /Symbol generator).	123	14%
Auto throttle/auto thrust system failure.	94	11%
Flight Director failure/unavailability or erroneous command indications.	71	8%
Flying control/trim malfunction.	71	8%
Flight Management (FMC/FMS/FMGC) failure.	55	6%
Electrical system malfunction.	35	4%
Hydraulic system loss.	33	4%
Engine failure.	27	3%
Yaw Damper failure/inoperative.	23	3%
Air Data Computer failure.	18	2%
System loss due to lightning strike	8	1%

4.2.4 Situations requiring manual flight due to external factors

- 729 pilots (83%) indicated that they had been faced with an external factor that required them to fly the aircraft manually (Q2.6).

703 pilots provided responses describing the occurrences which consisted of 9,334 words. Again, each response was individually analysed and the types of event were grouped thematically and quantified.

The results (see table 4.7) are the separate events that have happened to each pilot. Pilots may have experienced one or more of the events on multiple occasions. It would be unrealistic to expect a pilot to recall the precise number of each event experienced throughout their career (although a number of pilots did).

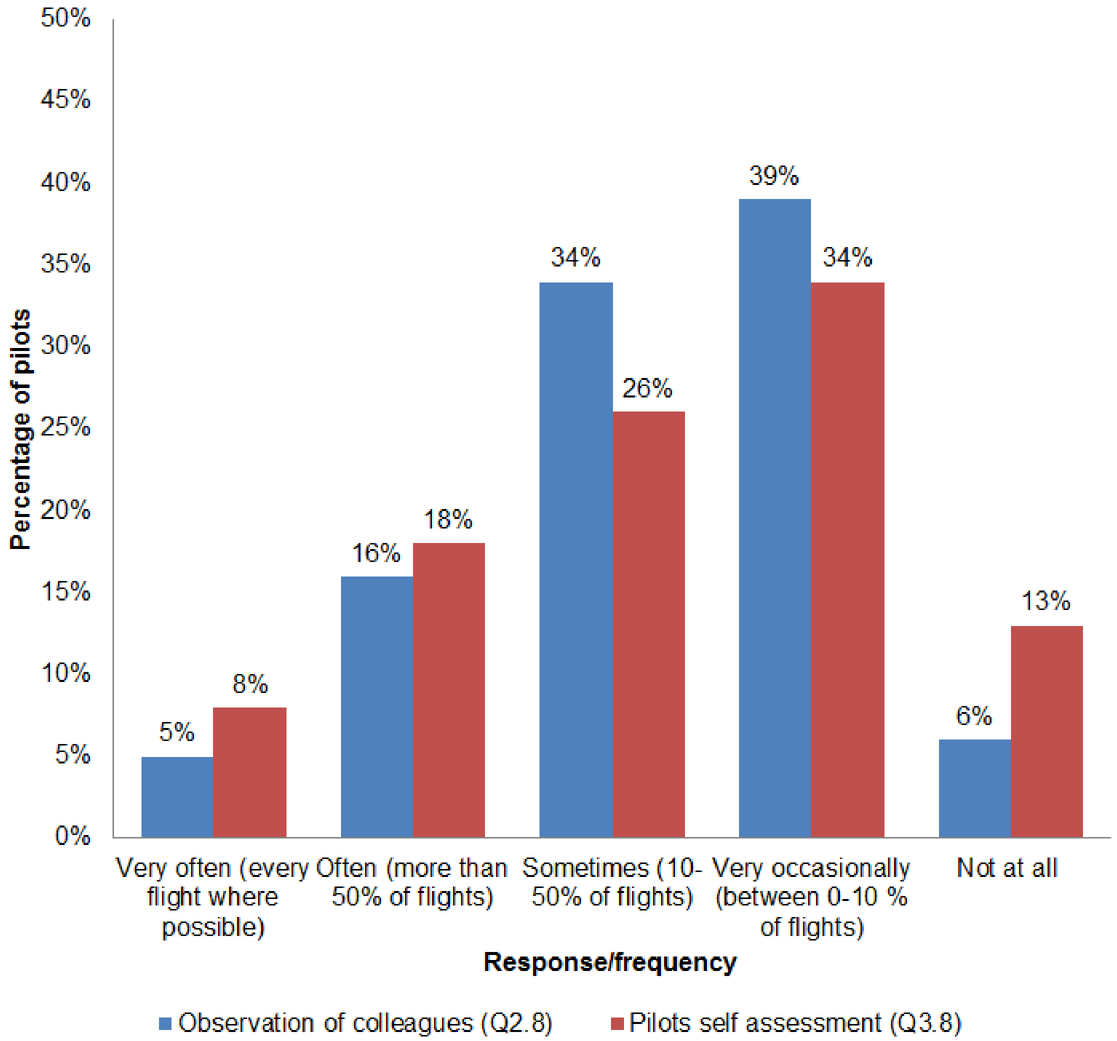
Table 4.7 Number of external events requiring manual flight

Type of event.	Number of respondents per event.	Percentage of as total of pilot population. (n=883)
Manoeuvring in response to TCAS Resolution Advisory.	386	44%
Turbulence (low and high altitude / CAT /orographic/mountain wave).	275	31%
Wake vortex/wake turbulence encounter.	138	16%
Avoidance manoeuvres (GPWS /birds/non-TCAS equipped traffic/ATC instruction).	108	12%
Other situations where manual flight required*. (See separate points below).	108	12%
Windshear recovery.	72	8%
Wind/gusts beyond autopilot limits on approach.	45	5%
Weather avoidance (short term).	21	2%
Severe icing.	12	1%
Aerodynamic upset recoveries.	7	1%

* Other situations where manual flight required:
  - Circling approaches.
  - Visual approaches.
  - No navigational aid available for landing/failure of ground based equipment.
  - Category IIIA hand flown approaches.
  - Over speed recovery/avoidance.
  - Immediate transfer of pilot control.
  - Autoland failure.
  - Displaced threshold.
  - Flight mode control error recovery.
  - Level bust avoidance.
  - Poor/slow autopilot response.

4.2.5 Amount of manual flying performed

Figure 4.3 Distribution of responses as to how often pilots observe colleagues practicing manual flying skills (Q2.8), and their own responses when asked how much manual flying they really do themselves (Q3.8).



4.2.6 Pilots' attitudes towards manual flying skills

Table 4.8 Pilot responses when asked about conducting a flight of one hour duration with the autoflight and/or autothrust system inoperative (assuming it is fitted and allowed under the aircraft's Minimum Equipment List and flight in RVSM airspace not required) (Q2.7).

#	Answer		Response	%
1	Very comfortable		292	33%
2	Somewhat comfortable		289	33%
3	Neutral		126	14%
4	Somewhat uncomfortable		157	18%
5	Very uncomfortable		19	2%
	Total		883	100%

Table 4.9 Pilot responses regarding concerns about a possible loss of manual flying skills with too much automation (Q2.9).

#	Answer		Response	%
1	Strongly agree		366	41%
2	Agree		376	43%
3	Neutral		71	8%
4	Disagree		62	7%
5	Strongly disagree		8	1%
	Total		883	100%

Table 4.10 Pilot responses relating to a decrease of manual flying skills if they are not practiced (Q2.10).

#	Answer		Response	%
1	Strongly agree		634	72%
2	Agree		223	25%
3	Neutral		16	2%
4	Disagree		9	1%
5	Strongly disagree		1	0%
	Total		883	100%

Table 4.11 Pilot responses when asked if they like to hand fly part of every flight to keep their skills up (Q2.11).

#	Answer		Response	%
1	Strongly agree		421	48%
2	Agree		338	38%
3	Neutral		85	10%
4	Disagree		35	4%
5	Strongly disagree		4	0%
	Total		883	100%

Table 4.12 Pilot responses when asked how they feel flying "raw data"? (Flight without flight director, autopilot/autothrust Q2.12)

#	Answer		Response	%
1	Very comfortable		230	26%
2	Somewhat comfortable		381	43%
3	Neutral		127	14%
4	Somewhat uncomfortable		129	15%
5	Very uncomfortable		16	2%
	Total		883	100%

Table 4.13 Pilot responses when asked if they feel their manual flying skills have been affected since they started flying automated aircraft (Q3.12).

#	Answer		Response	%
1	Yes, they have improved		68	8%
2	No, they have not changed		204	23%
3	Yes, they have deteriorated		611	69%
	Total		883	100%

Table 4.14 Pilot responses when asked how their manual flying skills will be in the future if they do not practice them (Q3.14).

#	Answer		Response	%
1	They will decline		812	92%
2	They will stay the same		65	7%
3	They will improve		6	1%
	Total		883	100%

Table 4.15 Pilot responses when asked if their manual flying skills have become degraded since they started flying automated aircraft (Q2.15).

#	Answer		Response	%
1	Strongly agree		234	27%
2	Agree		396	45%
3	Neutral		142	16%
4	Disagree		95	11%
5	Strongly disagree		16	2%
	Total		883	100%

4.2.7 Pilots perceptions of current manual flying skills

Figure 4.4 Comparison of perception of current manual flying skills (Self-perception and perception of others, with Training Captains' perception of others Q2.16 and Q2.19).

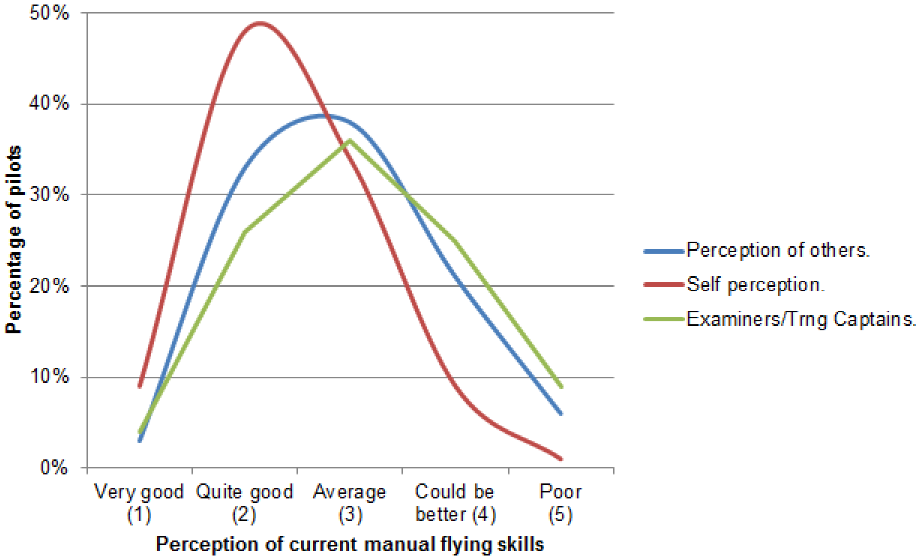


Table 4.16 Pilot responses when asked if they think it is necessary to improve basic airmanship and manual flying skills of pilots (Q2.20).

#	Answer		Response	%
1	Strongly agree		527	60%
2	Agree		313	35%
3	Neutral		34	4%
4	Disagree		8	1%
5	Strongly disagree		1	0%
	Total		883	100%

Table 4.17 Pilot responses when asked, "In order to maintain flying skills, do you think that manually flying an aircraft without the Flight Director would be more beneficial than hand flying but following a Flight Director?" (Q2.21).

#	Answer		Response	%
1	Strongly agree		380	43%
2	Agree		343	39%
3	Neutral		112	13%
4	Disagree		44	5%
5	Strongly disagree		4	0%
	Total		883	100%

4.2.8 Pilots' opinions on operator automation policies

- 56% of pilots thought a less restrictive automation policy would be the most effective way for them to improve or maintain manual flying skills (Q3.15)

Table 4.18 Pilot responses when asked about their operator's attitude to maintaining manual flying skills (Q2.14).

#	Answer		Response	%
1	Make use of automation at all times		179	20%
2	Use an appropriate level of automation as required		509	58%
3	Neutral		80	9%
4	Encouraged whenever possible		95	11%
5	Not specified		20	2%
	Total		883	100%

Table 4.19 Pilot responses when asked if their operator's automation policy was having a negative on maintaining manual their flying skills (Q2.17).

#	Answer		Response	%
1	Strongly agree		148	17%
2	Agree		229	26%
3	Neutral		287	33%
4	Disagree		193	22%
5	Strongly disagree		26	3%
	Total		883	100%

4.3 Training issues

- 75% of pilots have noticed a colleague practice manual flying (in the aircraft) prior to a proficiency check in a flight simulator (Q2.13).
- 72% of pilots have practiced manual flying prior to a proficiency check in a flight simulator (Q3.3).

Table 4.20 Pilot responses when asked if they would like more time available in the simulator to practice manual flying (Q3.1).

#	Answer		Response	%
1	Strongly agree		293	33%
2	Agree		376	43%
3	Neutral		140	16%
4	Disagree		65	7%
5	Strongly disagree		9	1%
	Total		883	100%

Table 4.21 Pilot responses when asked if their operator's recurrent training schedule allows sufficient training time to practice flying in the flight simulator (Q3.2).

#	Answer		Response	%
1	Yes		161	18%
2	Sometimes		399	45%
3	No		322	37%
	Total		882	100%

Table 4.22 Pilot responses when asked if they agreed there is not enough simulator time spent practicing manual flight (Q3.4).

#	Answer		Response	%
1	Strongly agree		225	25%
2	Agree		383	43%
3	Neutral		193	22%
4	Disagree		69	8%
5	Strongly disagree		13	1%
	Total		883	100%

Table 4.23 Pilot responses when asked if they thought modern simulator training/checking is too much of a scripted "box ticking" exercise (Q3.5).

#	Answer		Response	%
1	Strongly agree		269	30%
2	Agree		378	43%
3	Neutral		143	16%
4	Disagree		88	10%
5	Strongly disagree		5	1%
	Total		883	100%

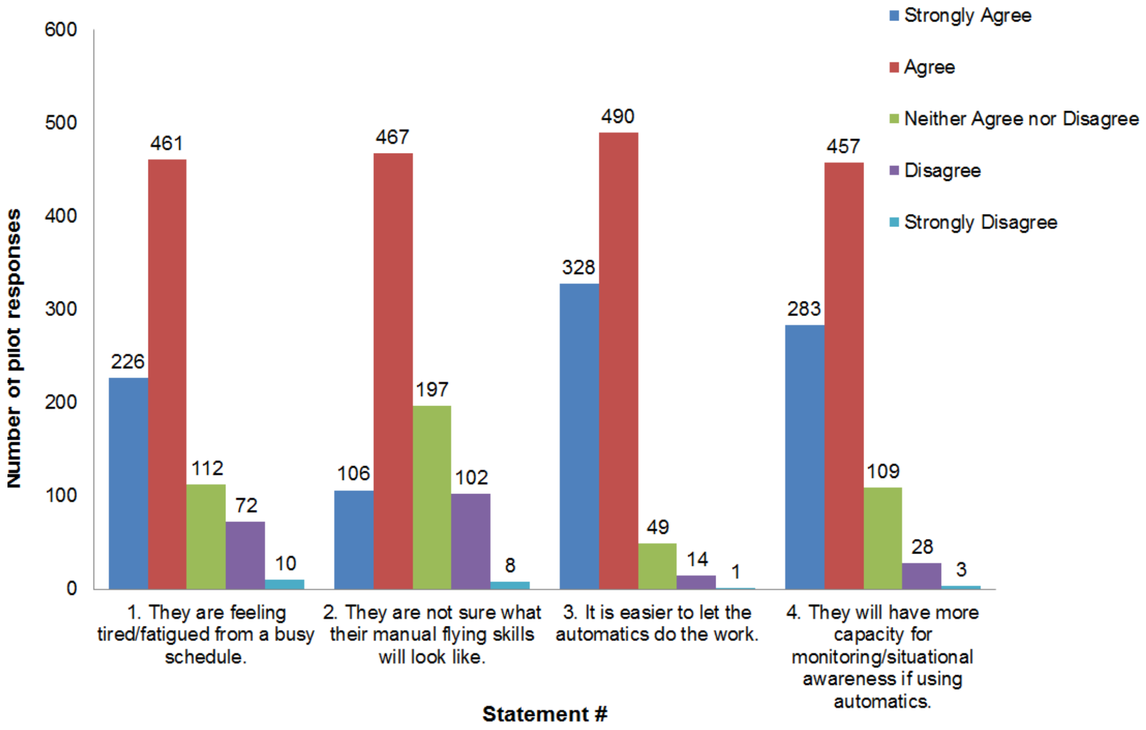
- 85% of pilots have received upset recovery/stall simulator training in the last 36 months (Q3.6).

Table 4.24 Pilot responses when asked, "should more emphasis be placed on using simulators to assess a pilot's manual flying skills" (Q3.7).

#	Answer		Response	%
1	Strongly agree		200	23%
2	Agree		421	48%
3	Neutral		185	21%
4	Disagree		69	8%
5	Strongly disagree		8	1%
	Total		883	100%

4.4 Factors which may cause reluctance to practice manual flight

Figure 4.5 Responses relating to statements as to why some pilots may be reluctant to practice manual flight (Q3.9).



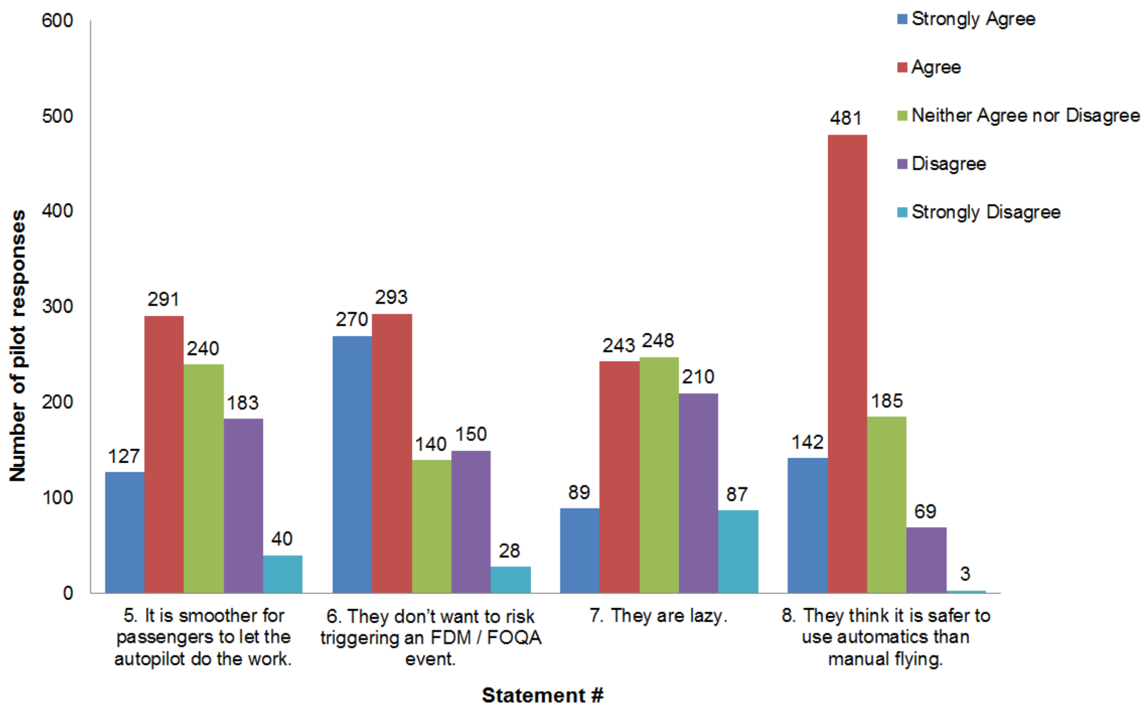
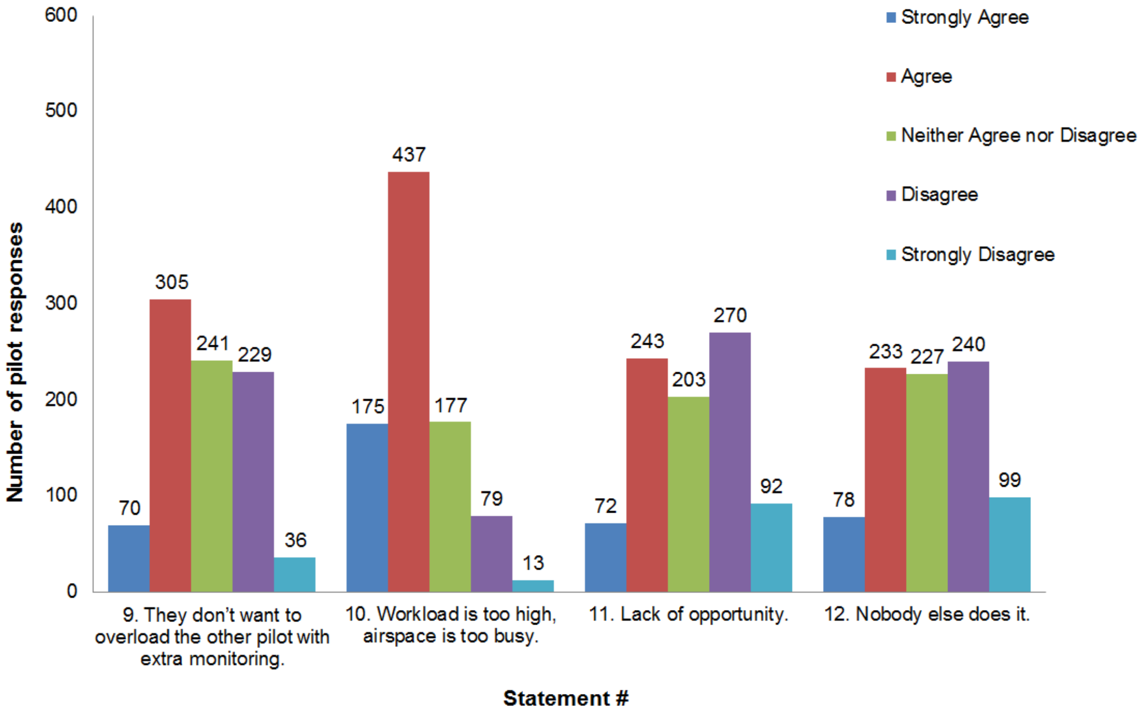


Figure 4.5 (continued) Responses relating to statements as to why some pilots may be reluctant to practice manual flight (Q3.9).



When asked to choose the one single statement which pilots think is the main reason they may be reluctant to practice (Q3.10), these were indicated to be :

- They don't want to risk triggering a FDM event 18% (158 pilots)
- It is easier to let the automatics do the work 17% (150 pilots)
- They are feeling fatigued 14% (125 pilots)
- They will have more monitoring capacity/SA 14% (120 pilots)
- They are not sure what their skills will look like 9% (83 pilots)

4.4.1 Workload and performance

Table 4.25 Pilot responses when asked if the workload in the flight deck would be increased to an unacceptable level for normal operations if the "Pilot Flying/Handling Pilot" was to fly a descent/approach manually, without the use of autopilots or flight directors (assuming that there was good weather and low traffic levels (Q4.1).

#	Answer		Response	%
1	Strongly agree		56	6%
2	Agree		130	15%
3	Neutral		112	13%
4	Disagree		397	45%
5	Strongly disagree		188	21%
	Total		883	100%

4.4.2 Fatigue

- 97% of pilots had noticed the performance of a colleague on the flight deck be affected by tiredness or fatigue (Q4.3).

Table 4.26 Pilot responses when asked if they believe airline/commercial schedules are generally just too busy, so that pilots may be too tired to practice manual flying (Q4.4).

#	Answer		Response	%
1	Strongly agree		208	24%
2	Agree		373	42%
3	Neutral		167	19%
4	Disagree		127	14%
5	Strongly disagree		8	1%
	Total		883	100%

Table 4.27 Pilot responses when asked if they had experienced tiredness or fatigue, after which they felt they could not fly the aircraft safely without automation (Q4.5).

#	Answer		Response	%
1	Strongly agree		176	20%
2	Agree		365	41%
3	Neutral		118	13%
4	Disagree		191	22%
5	Strongly disagree		32	4%
	Total		882	100%

4.4.3 Use of automation

Table 4.28 Pilot responses when asked if they thought it was safer to use full automation at all times (Q4.6).

#	Answer		Response	%
1	Strongly agree		23	3%
2	Agree		168	19%
3	Neutral		168	19%
4	Disagree		351	40%
5	Strongly disagree		173	20%
	Total		883	100%

4.4.4 Methods pilots use to maintain manual flying skill proficiency

Regarding recency in manual flying tasks with regards to performance (Q3.11):

- 53% indicated a pilot who (after basic training) started their career on automated aircraft, but practiced manual flight often, would be most likely to have better manual flying skills.
- 47% indicated a pilot who started their career flying a conventional aircraft before moving onto an automated aircraft, but does not practice manual flight, would be most likely to have better manual flying skills.

Table 4.29 Pilot responses when asked if they do flying outside of work (Q3.14).

#	Answer	Response	%
1	Gliding	47	5%
2	Light aircraft (fixed wing or rotary)	197	22%
3	Aerobatics	52	6%
4	Flight instruction	69	8%
5	I do no extra flying outside of work	639	72%

Table 4.30 Pilot responses when asked what they thought would be the most effective way for pilots to maintain or improve manual flying skills (Q3.15).

#	Answer	Response	%
1	More simulator training	268	30%
2	Less restrictive automation airline policy	491	56%
3	More assessment / regulation	31	4%
4	Extra training in light aircraft / gliders	93	11%
	Total	883	100%

Table 4.31 Pilot responses when asked which methods they use to maintain manual flying skill proficiency (Q4.9).

#	Answer	Response	%
1	Manually flying when the situation allows	671	76%
2	Flight simulators	266	30%
3	Flying outside of work	160	18%
4	Normal take offs and landings in line operation	522	59%

Table 4.32 Pilot responses when asked if they think some pilots are just "lazy/ too complacent" with regards to practicing manual flying (Q4.10).

#	Answer	Response	%
1	Strongly agree	124	14%
2	Agree	408	46%
3	Neutral	167	19%
4	Disagree	162	18%
5	Strongly disagree	22	2%
	Total	883	100%

4.4.5 Effect of other crew member

- 385 pilots (44%) indicated that they had been dissuaded from flying manually because their colleague on the flight deck felt uncomfortable (Q4.8).

4.4.6 Flight Data Monitoring

- Of the pilots who flew aircraft equipped with a Flight Data Monitoring system 281 (34%) pilots had been dissuaded from flying manually because they were mindful that they may trigger a FDM / FOQA event (Q4.7).

4.4.7 Visual approaches

Table 4.33 Pilot responses when asked how they would feel if Air Traffic Control offered a visual approach (flying to a previously visited destination, the weather is nice and traffic levels are low) (Q4.11).

#	Answer		Response	%
1	Very comfortable		496	56%
2	Somewhat comfortable		242	27%
3	Neutral		65	7%
4	Somewhat uncomfortable		69	8%
5	Very uncomfortable		11	1%
	Total		883	100%

4.5 Pilot opinions related to aircraft/flight deck design

Table 4.34 Pilot responses when asked if they thought angle of attack information (alpha) should be displayed directly to the pilots on all public transport aircraft types (Q5.1).

#	Answer		Response	%
1	Strongly agree		290	33%
2	Agree		281	32%
3	Neutral		243	28%
4	Disagree		63	7%
5	Strongly disagree		6	1%
	Total		883	100%

Table 4.35 Pilot responses when asked, "should there be more audio and visual warnings from aircraft designers to alert of low airspeed situations?"(Q5.2).

#	Answer		Response	%
1	Strongly agree		126	14%
2	Agree		237	27%
3	Neutral		310	35%
4	Disagree		192	22%
5	Strongly disagree		18	2%
	Total		883	100%

Table 4.36 Pilot responses when asked if they thought aircraft fitted with "trend vectors" on the primary flight display instruments, made manual flight a lot easier (Q5.4).

#	Answer		Response	%
1	Strongly agree		302	34%
2	Agree		446	51%
3	Neutral / Not applicable		105	12%
4	Disagree		28	3%
5	Strongly disagree		2	0%
	Total		883	100%

Table 4.37 Pilot responses when asked if there was benefit in practicing manual flight in aircraft with full flight envelope protection (fly by wire/auto-trim) (Q5.5).

#	Answer		Response	%
1	Strongly agree		299	34%
2	Agree		324	37%
3	Neutral		146	17%
4	Disagree		82	9%
5	Strongly disagree		32	4%
	Total		883	100%

- With regards to airspeed monitoring, 57% of pilots indicated it is easier to notice a large airspeed deviation from an EFIS "speed tape" type display, compared to a traditional round dial "analogue" airspeed indicator (Q5.3).

4.6 Monitoring

Table 4.38 Pilot responses when asked if autothrottle/autothrust systems have changed the way they monitor indicated airspeed (Q5.6).

#	Answer		Response	%
1	Less monitoring is required		359	41%
2	It has stayed the same		326	37%
3	More monitoring is required		121	14%
4	Not Applicable / Not fitted to my aircraft type		77	9%
	Total		883	100%

Table 4.39 Pilot responses when asked if monitoring skills are equally as important as good manual flying skills (Q5.7).

#	Answer		Response	%
1	Strongly agree		502	57%
2	Agree		354	40%
3	Neutral		14	2%
4	Disagree		11	1%
5	Strongly disagree		2	0%
	Total		883	100%

Table 4.40 Pilot responses on how they would perceive their fellow pilots' monitoring skills at the moment (Q5.9).

#	Answer		Response	%
1	Very good		155	18%
2	Quite good		467	53%
3	Average		208	24%
4	Could be better		49	6%
5	Poor		4	0%
	Total		883	100%

- 451 pilots (51%) have received specific guidance from their operator with regards to maintaining or improving monitoring skills (Q5.8).

4.7 Thematic analysis of additional information

Free text/additional responses at the end of the survey were recorded from 317 respondents. This data was of a qualitative nature. The written comments included a total of 22,686 words (after non-pertinent information was removed). The responses varied from single sentences to five-hundred word essays, with many respondents writing several hundred words each.

All data was transferred from the Qualtrics software, then analysed using a Microsoft Excel database, then transferred to a Word document.

Multiple comments were also received by e-mail, but they are not included, as the means in which they were gathered did not form part of the survey and anonymity could have been compromised.

The analysis identified several main themes, these being:

- Automation policies.
- Flight Data Monitoring/FDAP/FOQA.
- Fatigue.
- Training.
- Differences between Captains and First Officers.
- Confidence.

Samples of these comments may be seen in the discussion in chapter 5.

4.8 Results by sub group

The gathered data was divided into sub-groups for further analysis and comparison between groups. The group comparisons were as follows:

- Age groups (46-65 and 18-35).
- Type of operation (Long-haul or short haul).
- Initial flying training background (civil or military).
- Pilot function (Captain or First Officer).
- Flying hours (high hours or low hours).
- Region (UK, Europe, Middle East, Asia, North America and South America).

There were a total of nine regions, but only those which had a sample population of greater than 50 pilots were used in order to be able to provide meaningful statistical comparisons.

Where there were noticeable differences between sub-groups (generally more than a 10% difference in response to a question) these were put into a tabular form and may be seen in Appendix A.

The corporate/business aviation group was also examined independently and compared to the remaining population.

An analysis of MPL trained pilots was carried out, however due to the relatively small sample size of nineteen (which is comparable to real world proportion of MPL pilots in the current population), this is included for information only.

Sufficient data was also available to compare responses by aircraft type:

- Medium jet transport: Airbus A320 series against Boeing 737 series.
- Large jet transport: Airbus A330 against Boeing 777.

The commonly used statistical significance value of $p<0.05$ was used to determine significance of the results, with p being the probability of obtaining a test statistic result, i.e. simply put, there is less than a 5% probability that the results have occurred by chance.

Part of the aims and objectives of this study was to establish any differences in the amount of manual flying performed by different sub-groups. The statistical comparisons were carried out using "chi-squared" tests, as these were deemed to be the most appropriate tests for association between two categorical variables, such as between the group of Captains and First Officers. For this task the responses from question 3.8 were used, which asked how much manual flying did the pilots really do apart from take-off or landing? It was not suitable to use the responses from question 2.8, which was how often pilots observe their colleagues practicing manual flying, as their colleagues may fall into several different sub-groups, such as different age, number of flying hours, or training background. It was also decided to compare the sub-groups as to how comfortable they felt flying "raw data" (flight without use of autopilot, flight director or autothrust). The results may be seen in tabular form in Tables 4.41 and 4.42.

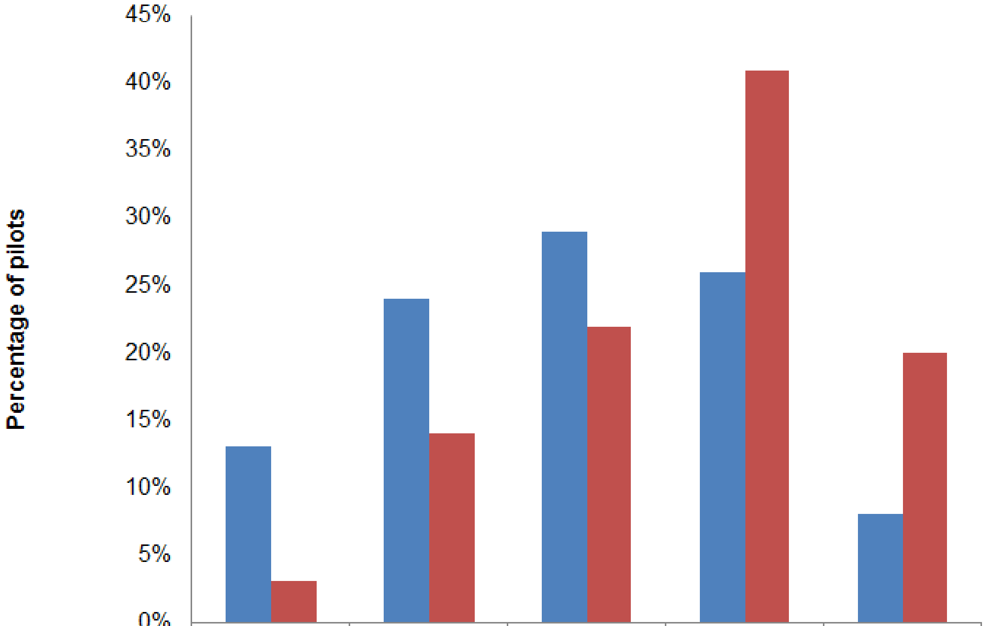
For ease of interpretation, those groups which had statistically significant differences can be seen in graphical form in figures 4.6 to 4.12.

4.8.1 Statistical comparison by sub-group

Table 4.41 Summary of statistical tests between sub-groups relating to survey responses on how much manual flying pilots really do other than take-off or landing (Q3.8).

Comparison	Group 1	Group 2	Chi-squared statistic	p value	Significant i.e. p< 0.05
Age	18 to 35 years old n=273	46 to 65 years old n=349	9.4835	0.050088	No
Type of operation	Long-haul n=237	Short-haul n=318	47.3249	< 0.00001	Yes
Type of operation	Corporate/ business jets n=71	Public transport n=812	25.0922	0.000048	Yes
Initial flying training background	Civil n=741	Military n=142	5.0198	0.285274	No
Pilot Function	Captains n= 469	First Officers n=414	28.4194	< 0.00001	Yes
Flying hours	200 to1,500 hours n=147	15,000+ Hours n=194	6.3857	0.172139	No
Aircraft type	Boeing 737 n=116	Airbus A320 series n=160	27.7314	< 0.00001	Yes
Aircraft type	Boeing 777 n=122	Airbus A330 n=127	1.8209	0.768661	No
Aircraft type	Regional Jets n=39	Regional Turboprop n=67	8.3562	0.079367	No

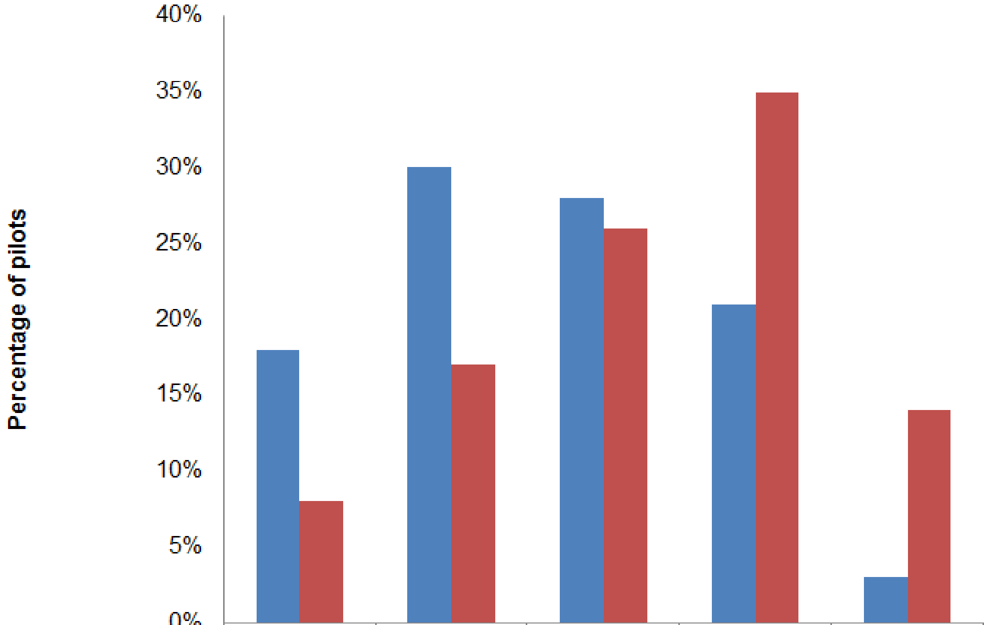
Figure 4.6 Comparison of long-haul/short-haul pilots regarding amount of manual flying performed.



	Very often	Quite often	Sometimes	Rarely	Never
SHORT-HAUL	13%	24%	29%	26%	8%
LONG-HAUL	3%	14%	22%	41%	20%

Response

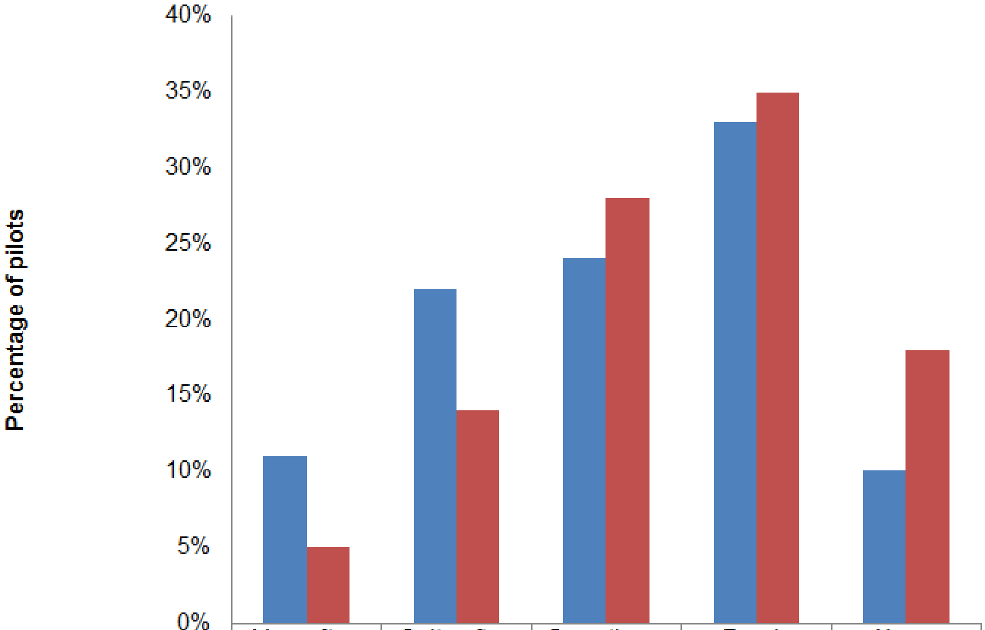
Figure 4.7 Comparison of Business Aviation/Airline pilots regarding amount of manual flying performed.



	Very often	Quite often	Sometimes	Rarely	Never
BUSINESS JETS	18%	30%	28%	21%	3%
AIRLINE	8%	17%	26%	35%	14%

Response

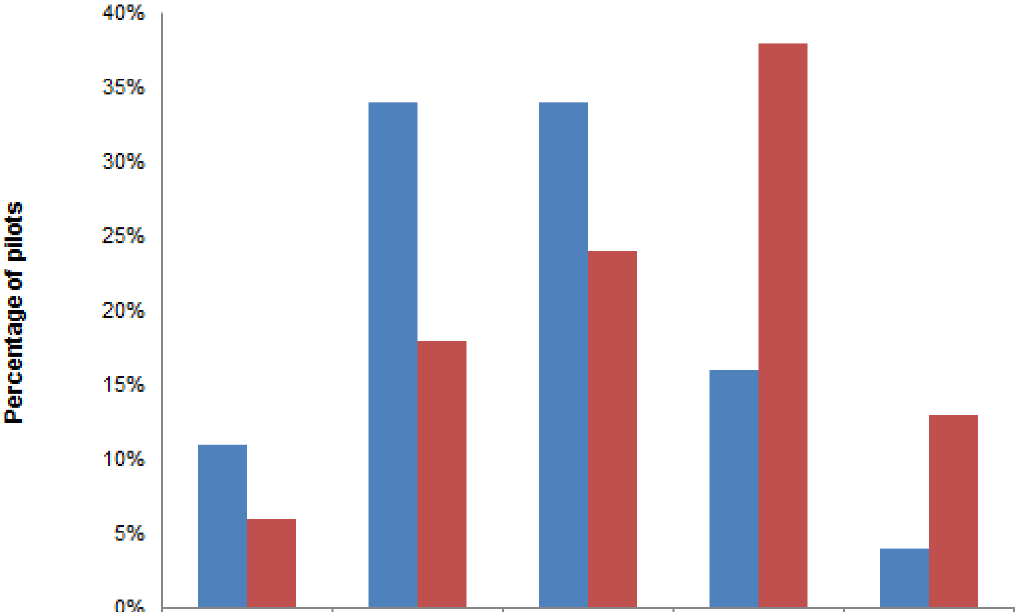
Figure 4.8 Comparison of Captains/First Officers regarding amount of manual flying performed.



	Very often	Quite often	Sometimes	Rarely	Never
CAPTAINS	11%	22%	24%	33%	10%
FIRST OFFICERS	5%	14%	28%	35%	18%

Response

Figure 4.9 Comparison of Boeing 737/A320 pilots regarding amount of manual flying performed.



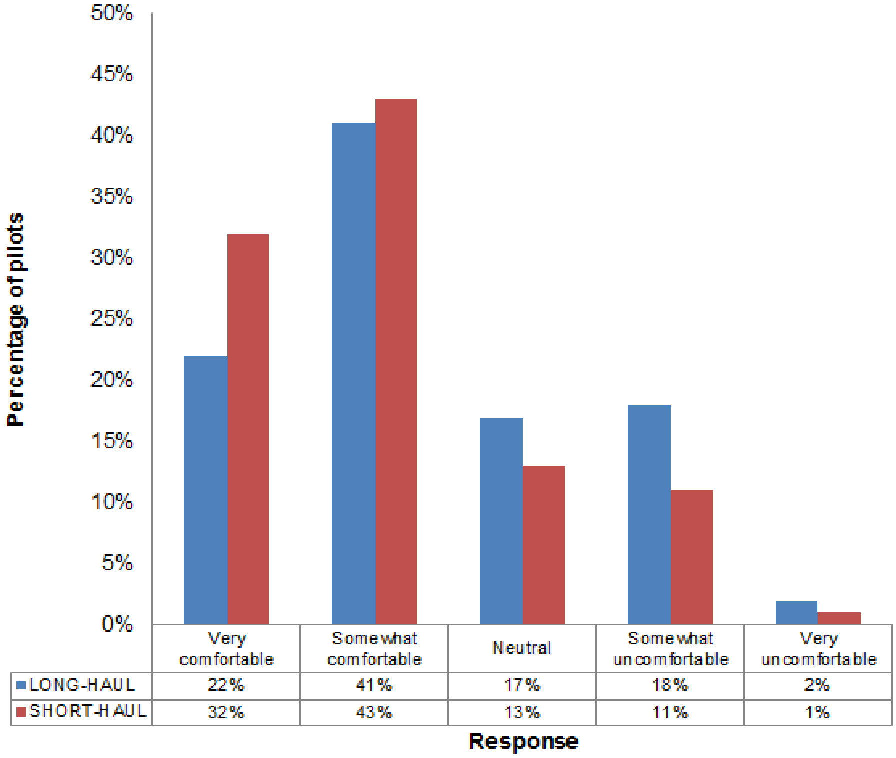
	Very often	Quite often	Sometimes	Rarely	Never
BOEING 737	11%	34%	34%	16%	4%
A320 Series	6%	18%	24%	38%	13%

Response

Table 4.42 Summary of statistical tests between sub-groups relating to survey responses on how comfortable pilots feel flying "raw data" (Q2.12).

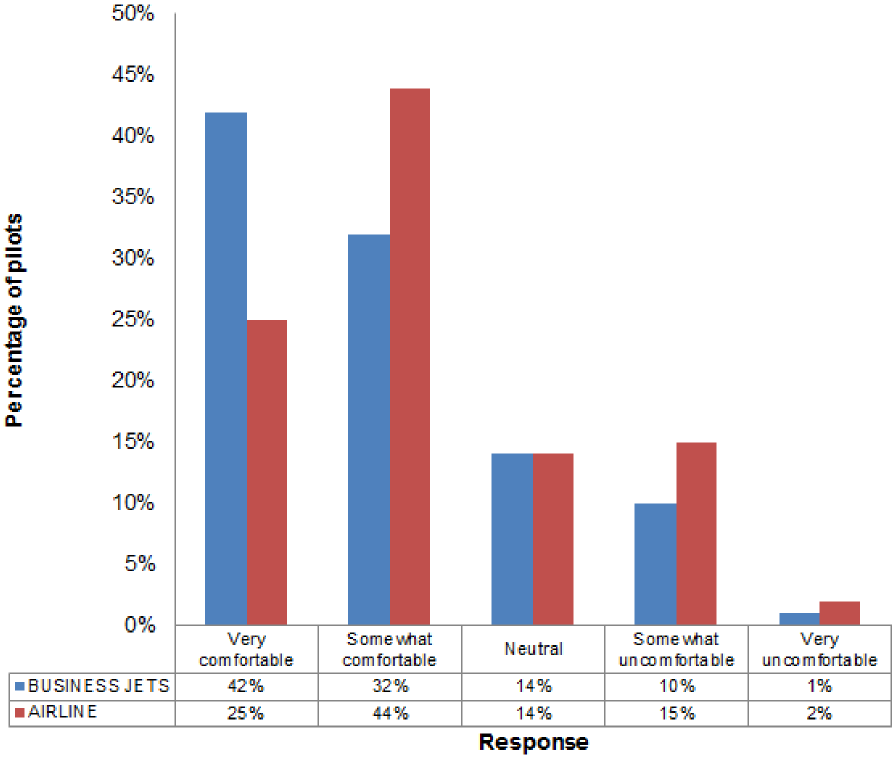
Comparison	Group 1	Group 2	Chi-squared statistic	p value	Significant i.e. p< .005
Age	18 to 35 years old n=273	46 to 65 years old n=349	2.0175	0.732537	No
Type of operation	Long-haul n=237	Short-haul n=318	12.6966	0.012857	Yes
Type of operation	Corporate/ business jets n=71	Public transport n=812	11.1705	0.024713	Yes
Initial flying training background	Civil n=741	Military n=142	2.6972	0.6097	No
Pilot Function	Captains n= 469	First Officers n=414	7.9125	0.094836	No
Flying hours	200 to1,500 hours n=147	15,000+ Hours n=194	3.5057	0.477014	No
Aircraft type	Boeing 737 n=116	Airbus A320 series n=160	12.8918	0.011817	Yes
Aircraft type	Boeing 777 n=122	Airbus A330 n=127	7.4084	0.115815942	No
Aircraft type	Regional Jets n=39	Regional Turboprop n=67	2.5408	0.467956	No

Figure 4.10 Comparison of long-haul/short-haul pilots regarding how comfortable they felt flying "raw data".



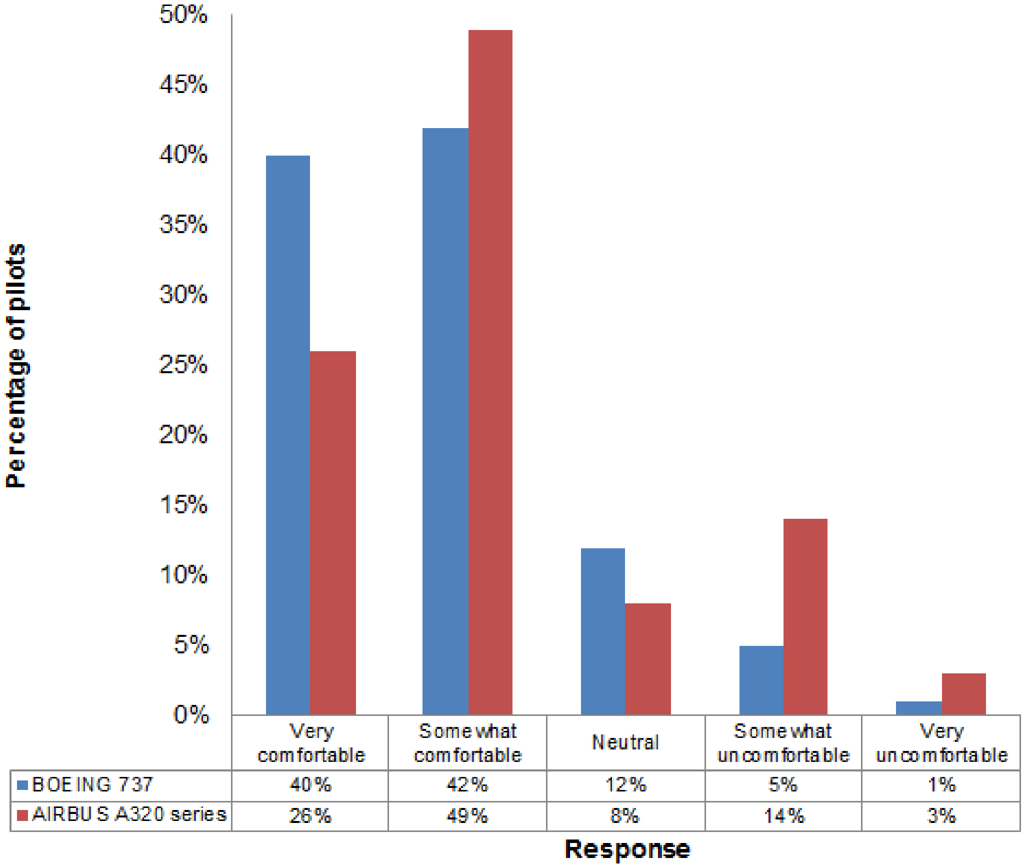
	Very comfortable	Somewhat comfortable	Neutral	Somewhat uncomfortable	Very uncomfortable
LONG-HAUL	22%	41%	17%	18%	2%
SHORT-HAUL	32%	43%	13%	11%	1%

Figure 4.11 Comparison of Business Aviation/Airline pilots regarding how comfortable they felt flying "raw data"



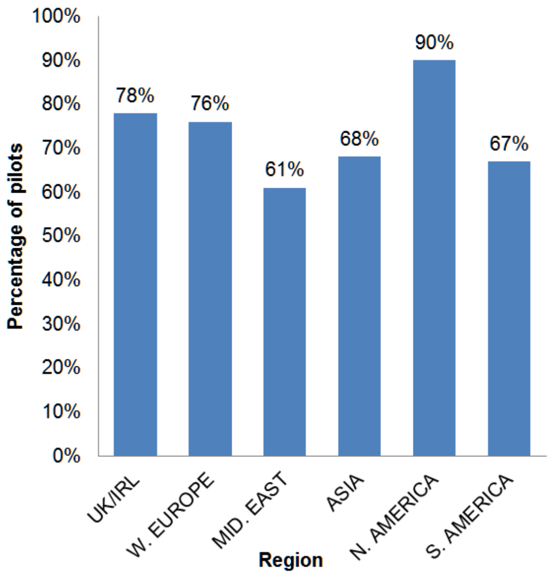
	Very comfortable	Somewhat comfortable	Neutral	Somewhat uncomfortable	Very uncomfortable
BUSINESS JETS	42%	32%	14%	10%	1%
AIRLINE	25%	44%	14%	15%	2%

Figure 4.12 Comparison of Boeing 737/A320 series pilots regarding how comfortable they felt flying "raw data"

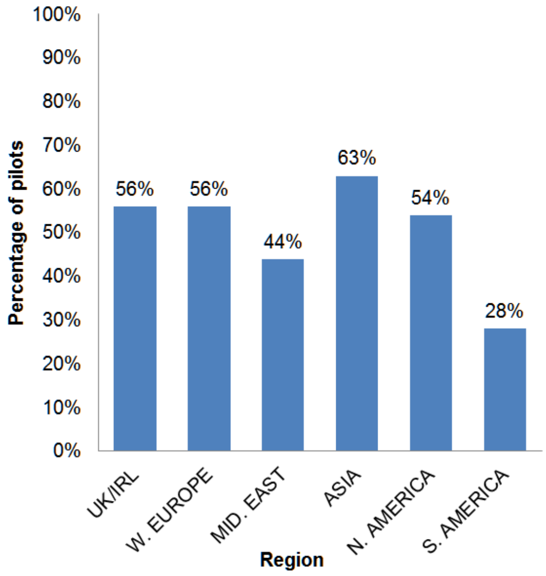


4.8.2 Comparison by region

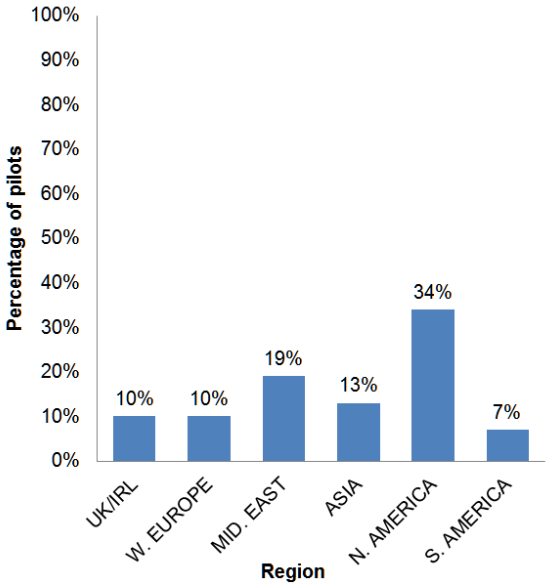
Figure 4.13 Histograms showing responses by region where differences were apparent in responses to relevant questions, numerical data is in Appendix A.9.



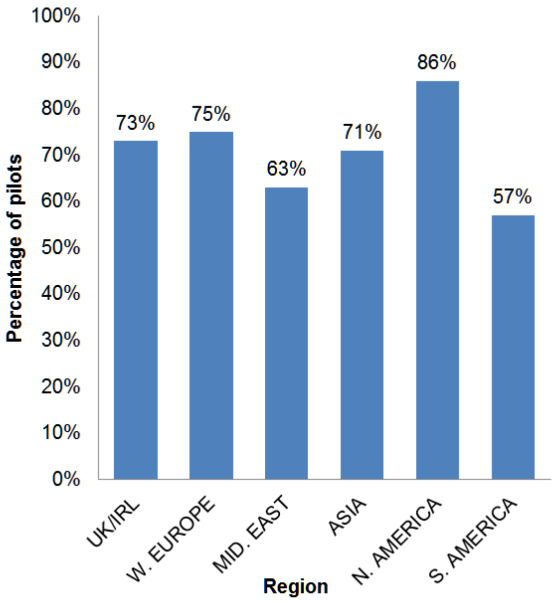
■ Q2.2 Percentage of pilots by region who have experienced failure of a flight guidance system or autopilot (in flight).



■ Q2.3 Percentage of pilots by region who have received from their operator any guidance regarding maintaining manual flying skills.

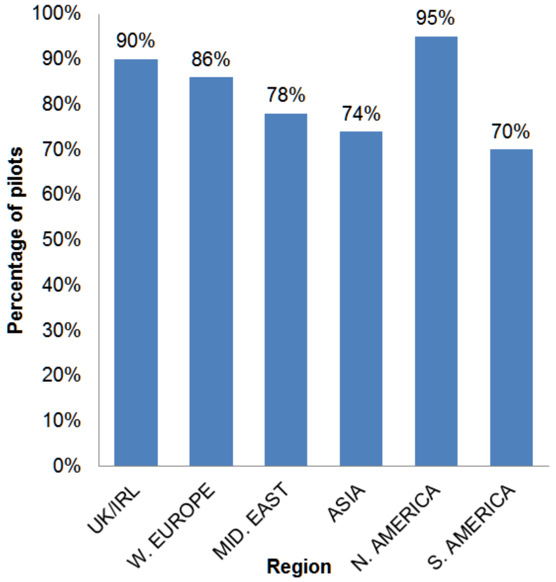


■ Q2.4 Percentage of pilots by region who have received from their regulator any guidance regarding maintaining manual flying skills.

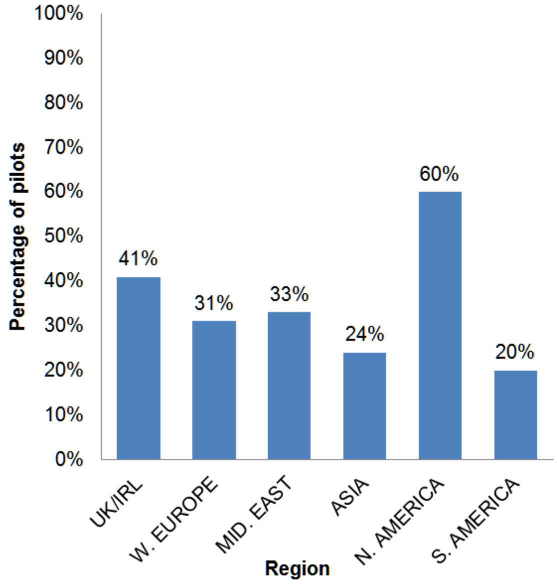


■ Q2.5 Percentage of pilots by region who have had an in-flight aircraft system or equipment failure that required them to fly the aircraft manually.

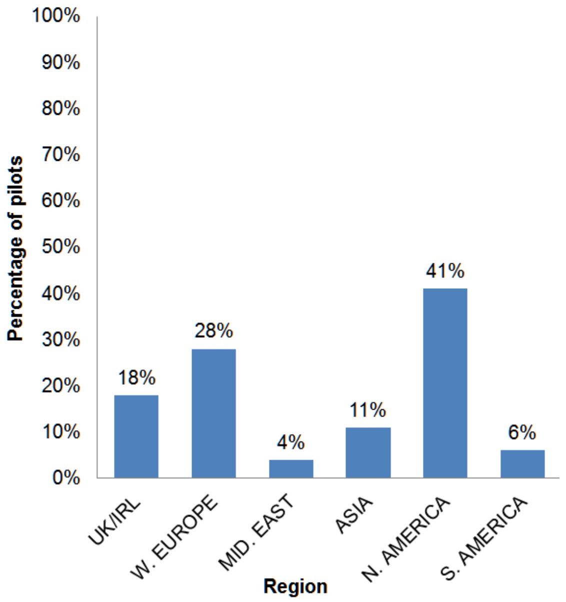
Figure 4.13 (continued) Histograms showing responses by region where differences were apparent in responses to relevant questions.



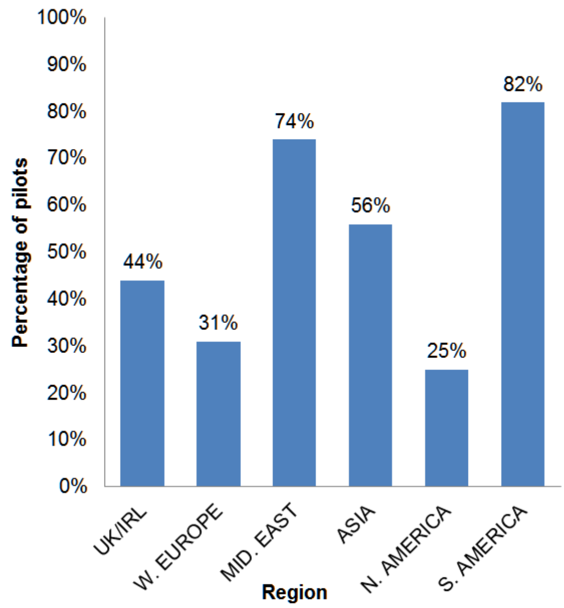
Q2.6 Percentage of pilots by region who have had an external factor that required them to fly the aircraft manually.



Q2.7 Percentage of pilots by region who feel very comfortable about conducting a flight of 1 hour duration with the AP and/or AT system inop.

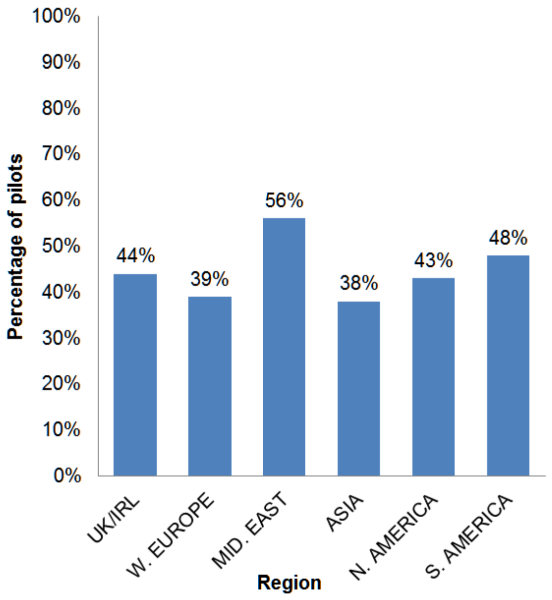


Q2.8 Percentage of pilots by region who see colleagues practice manual flying skills often and very often.

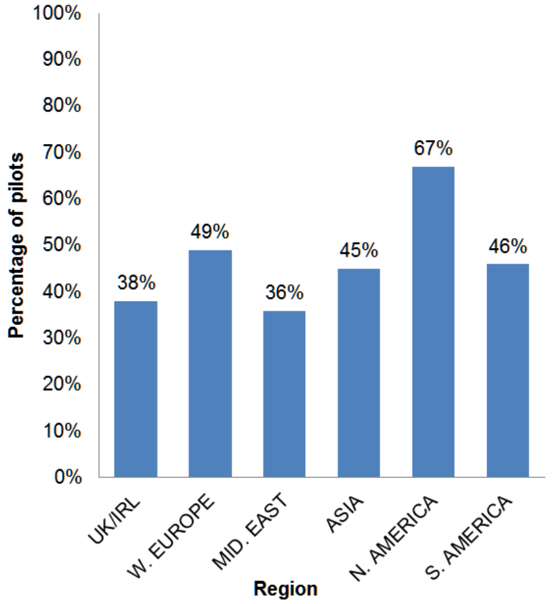


Q2.8ii Percentage of pilots by region who see colleagues practice manual flying skills very occasionally or not at all.

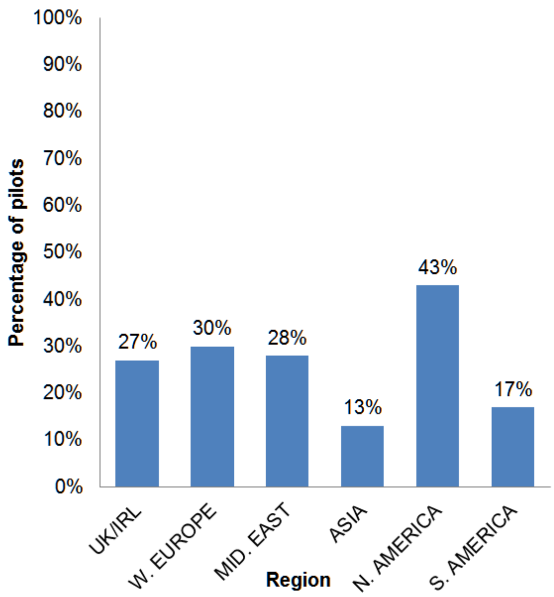
Figure 4.13 (continued) Histograms showing responses by region where differences were apparent in responses to relevant questions.



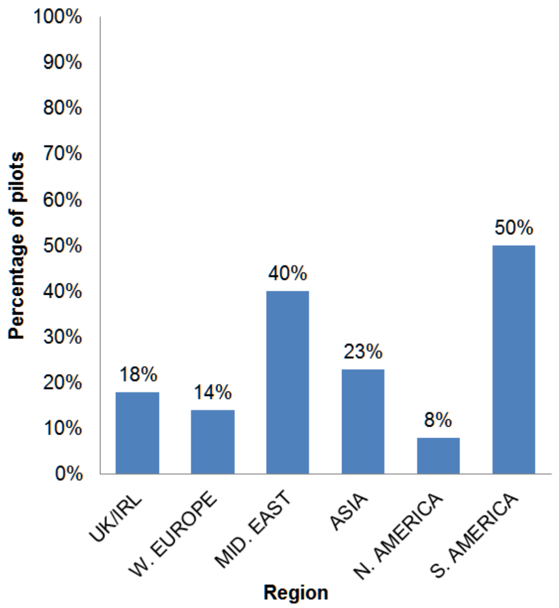
Q2.9 Percentage of pilots by region who strongly agreed about a possible loss of manual flying skills with too much automation.



Q2.11 Percentage of pilots by region who strongly agree they like to hand fly part of every flight to keep their skills up.

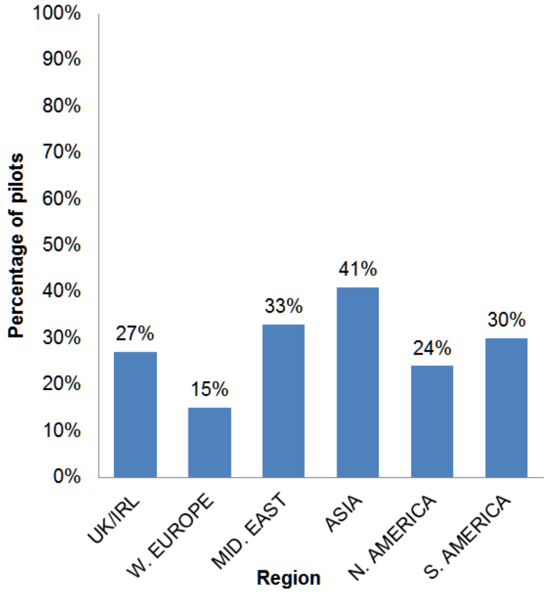


Q2.12 Percentage of pilots by region who feel very comfortable flying "raw data" (Flight without FD/AP/AT).

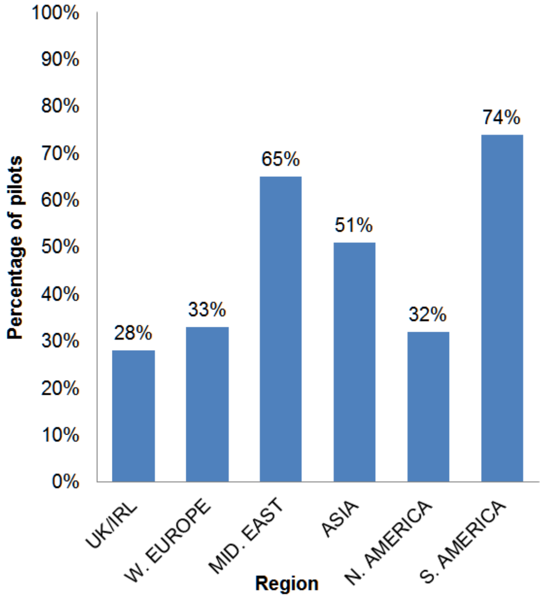


Q2.14 Percentage of pilots by region whose operator’s attitude to maintaining manual flying skills is “make use of automation at all times.”

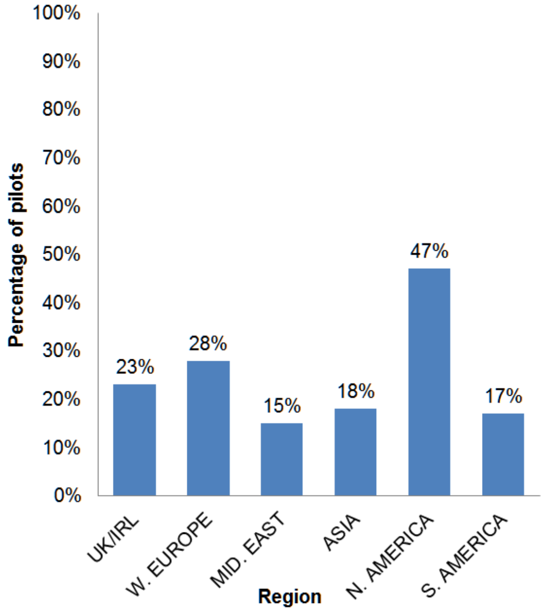
Figure 4.13 (continued) Histograms showing responses by region where differences were apparent in responses to relevant questions.



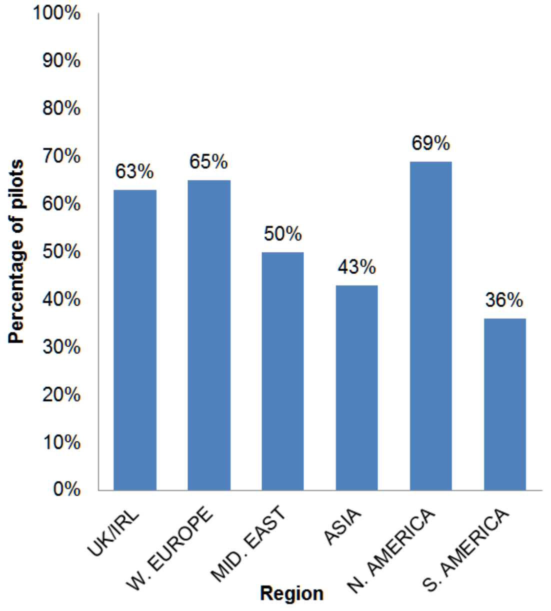
■ Q2.15 Percentage of pilots by region who strongly agreed their manual flying skills have become degraded since you started flying automated aircraft.



■ Q2.17 Percentage of pilots by region who agree/ strongly agree that their operator's automation policy has a negative effect on maintaining manual flying skills.

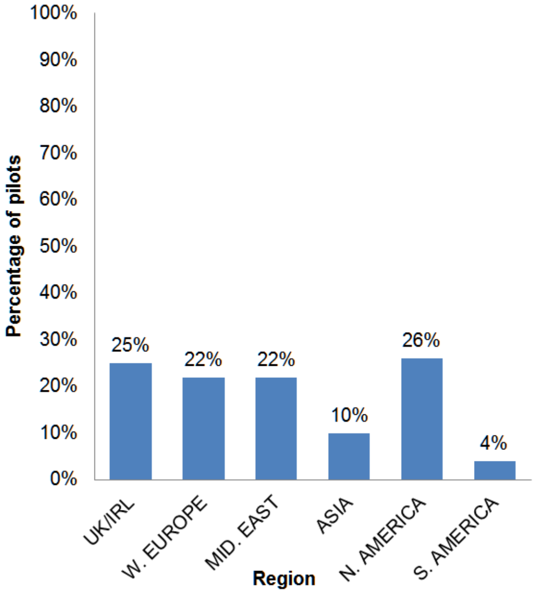


■ Q2.18 Percentage of pilots by region who practice their manual flying skills very often.

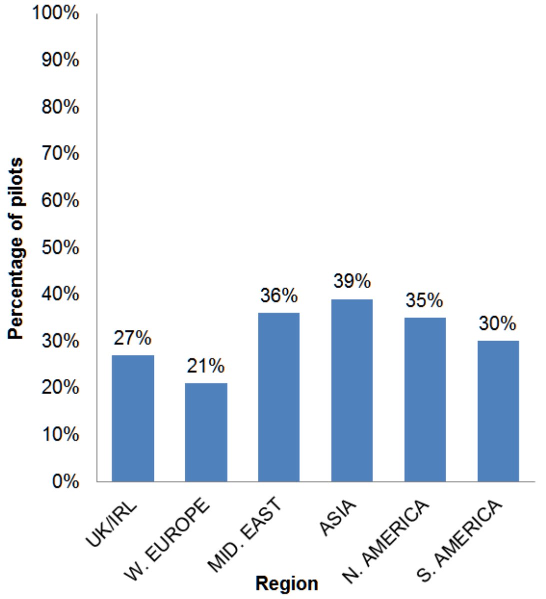


■ Q2.19 Percentage of pilots by region who perceive their manual flying skills to be currently quite good or very good.

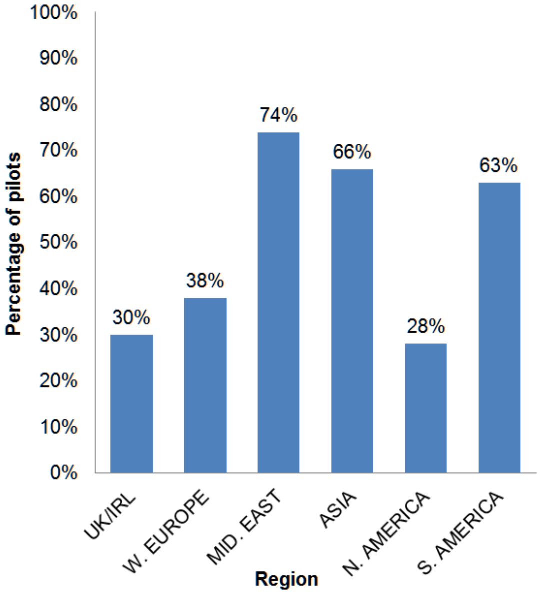
Figure 4.13 (continued) Histograms showing responses by region where differences were apparent in responses to relevant questions.



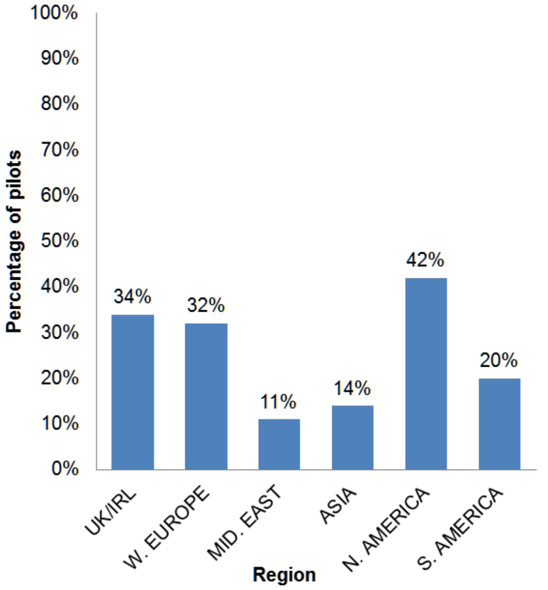
■ Q3.2 Percentage of pilots by region whose operators' recurrent training schedules allows sufficient time to practice manual flying in the simulator.



■ Q3.5 Percentage of pilots by region who strongly agree modern simulator recurrent training/checking is too much of a scripted "box ticking" exercise.

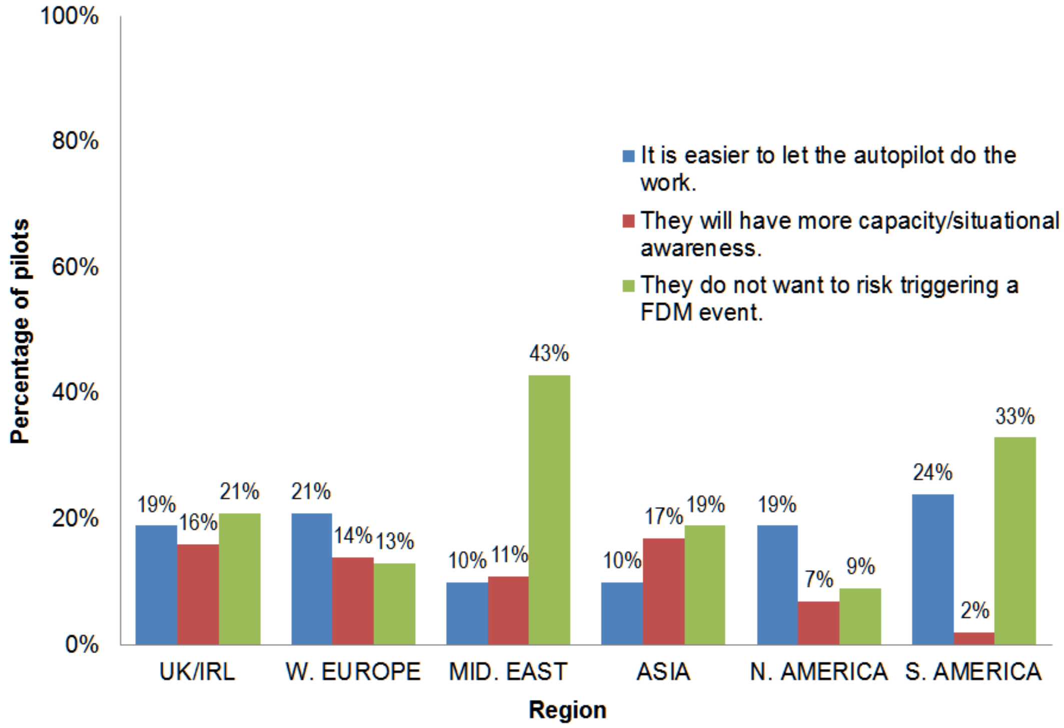


■ Q3.8 Percentage of pilots by region who never or rarely (apart from take-off and landing) fly manually.

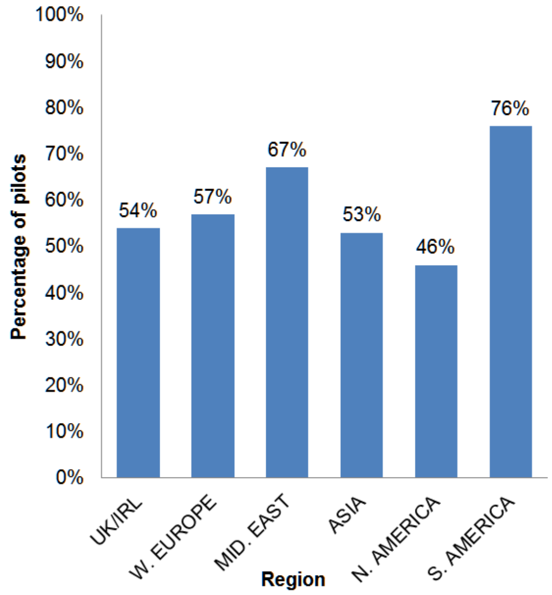


■ Q3.8 ii Percentage of pilots by region who quite often or very often (apart from take-off and landing) fly manually.

Figure 4.13 (continued) Histograms showing responses by region where differences were apparent in responses to relevant questions.

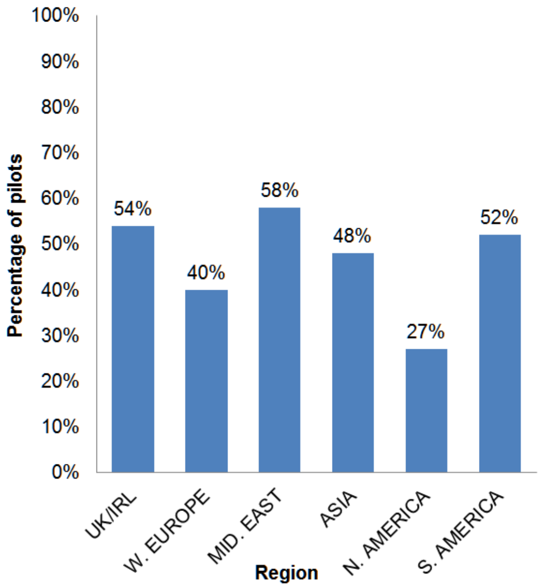


Q3.10 Main reason(s) pilots may be reluctant to practice manual flying (percentage of pilots by region).

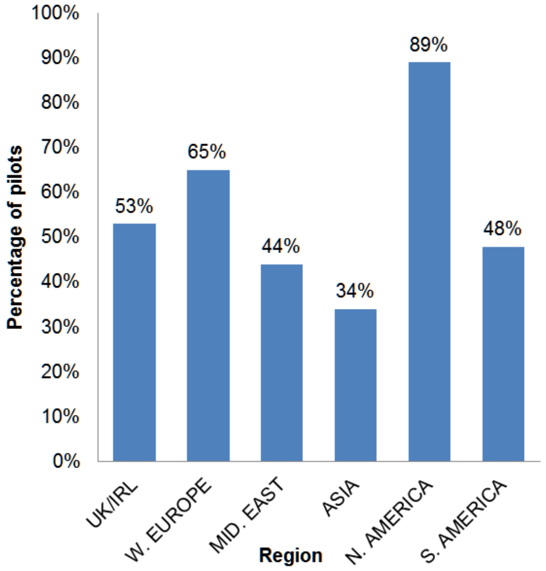


Q 3.15 Percentage of pilots by region who feel a less restrictive automation policy would be the most effective way to maintain/improve manual flying skills.

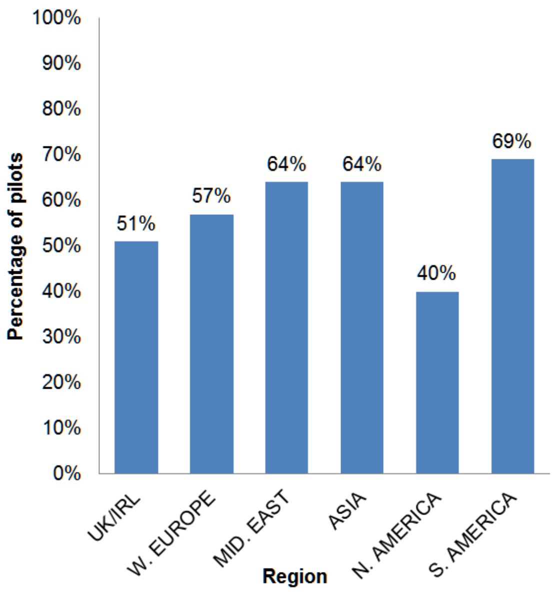
Figure 4.13 (continued) Histograms showing responses by region where differences were apparent in responses to relevant questions.



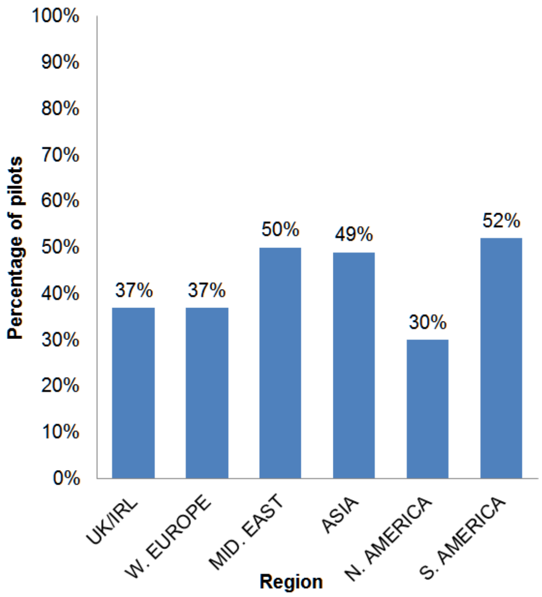
■ Q 4.8 Percentage of pilots by region who have ever been dissuaded from flying manually because their colleague on the flight deck felt uncomfortable.



■ Q 4.11 Percentage of pilots by region who felt very comfortable flying to a destination that they have previously visited and Air Traffic Control offers them a visual approach; the weather is nice and traffic levels are low.

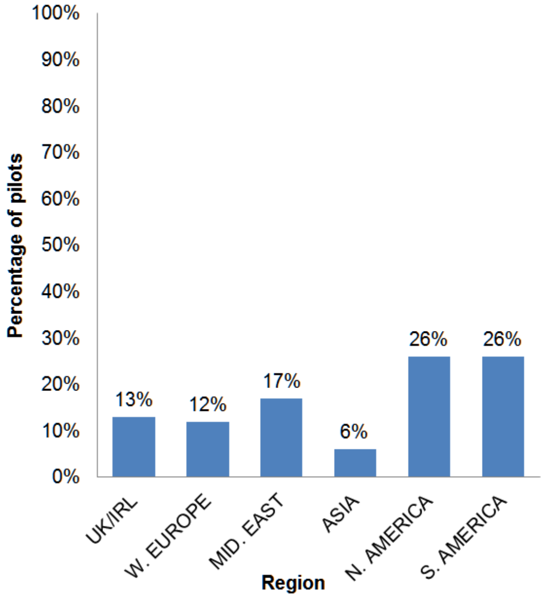


■ Q 5.3 Percentage of pilots by region who feel it is easier to notice a large airspeed deviation from an EFIS "speed tape" type display, when compared to a traditional round dial "analogue" airspeed indicator.

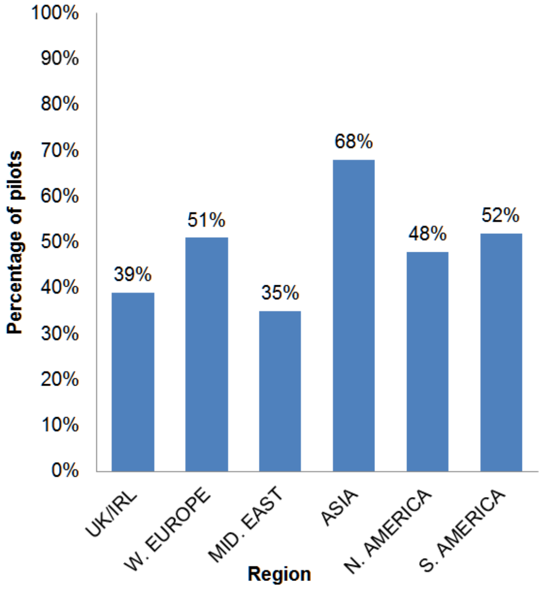


■ Q 5.6 Percentage of pilots by region who feel that autothrottle / autothrust has changed the way they monitor their indicated airspeed and requires less monitoring.

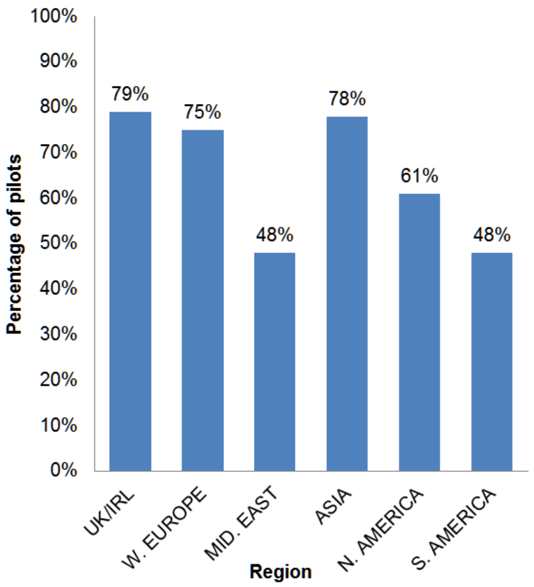
Figure 4.13 (continued) Histograms showing responses by region where differences were apparent in responses to relevant questions.



Q 5.6 ii Percentage of pilots by region who feel that autothrottle / autothrust has changed the way they monitor their indicated airspeed and requires more monitoring.



Q5.8 Percentage of pilots by region who have from their operator any specific guidance with regards to maintaining or improving monitoring skills.



Q5.9 Percentage of pilots by region who perceive their fellow pilots' monitoring skills are very good or quite good.

5. Discussion

The results obtained in chapter 4 are discussed with respect to the research objectives. The aims of this research were to ascertain pilots' perceptions on manual flying skills. The sample pilot population represents a wide variety of nationalities, ages, backgrounds and experience.

5.1 Limitations to this research

Given the large quantity of data collected covering the various issues related to manual flying, it was only possible to do limited statistical significance testing. The number of different sub-groups and different permutations possible from the large number of questions meant limited space was available to present the results. As such, the results are intended as a general overview of the pilot community.

Measuring pilots' perceptions or attitudes is highly subjective, and one pilot's way of assessing something may be very different from another. The pilots were required to report on their own behaviour, and so may have been somewhat reluctant to identify any shortcomings in their own ability. Some of the responses to the Likert type questions, such as “very comfortable” or “very good” may be hard to assess. Categories such as “comfort” or “goodness” are not well defined and such terms should be taken as being relative.

Many of the respondents may not have English language as their first language. Although pilots are required by law to have a certain level of English language proficiency, it is possible that if the survey had been translated into several other languages then more responses would have been possible from certain regions, since several of the pilots' associations contacted did not reply. Also given that the survey was “quite lengthy”, this may have accounted for the number of incomplete surveys.

Regions such as Asia and South America are made up of many countries and the respondents likely only came from a limited number of countries within those areas. The respondents from each region may not reflect pilots' perceptions in those regions as whole. However, it was felt grouping the respondents by region instead of country, would better preserve participant anonymity, as certain aircraft types may only be operated by one operator in a particular country.

The group of Second Officers (cruise relief pilots) are generally not allowed by their operators to fly the aircraft manually, other than in the simulator, as they are only allowed to sit in an operating seat above 20,000ft. So a small number of questions would not have been applicable to them. However given that this was 2% of the population it is not considered significant.

5.2 Comparison to relevant parts of previous surveys

The majority of pilots agreed that they are concerned about a loss of manual flying skills with too much automation (Q2.9). When compared to elements of previous surveys (Curry, 1985; Wiener, 1989) in figures 5.1 and 5.2, it can be seen there is a noticeable shift in pilots' responses towards agreeing that too much automation is possibly going to cause a loss of manual flying skills (see figure 5.3). This may be partly due to there being a far greater proportion of more "automated" aircraft designs in service today when compared to the 1980s and mid-1990s. Pilots who have flown these automated aircraft now have greater exposure to these types than compared to those in the previous surveys. There may also be greater awareness of several accidents where automation dependency or poor manual flying skills have been a factor.

Figure 5.1 Results of Curry's (1985) survey.

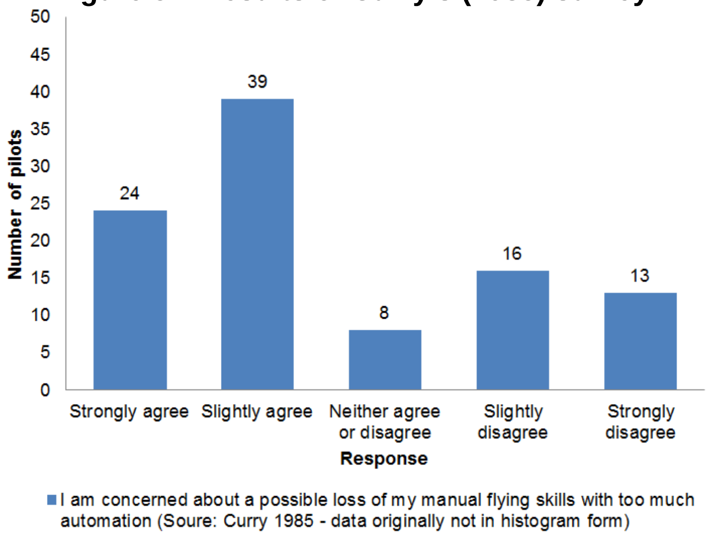


Figure 5.2 Results from Wiener's (1989) survey (source Wiener, 1989).

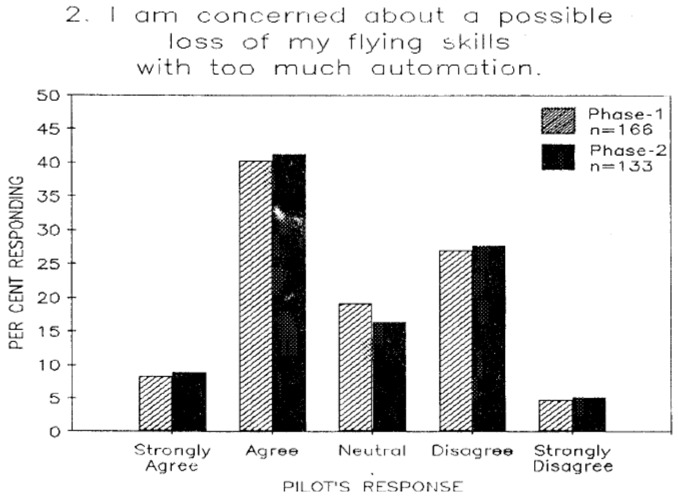
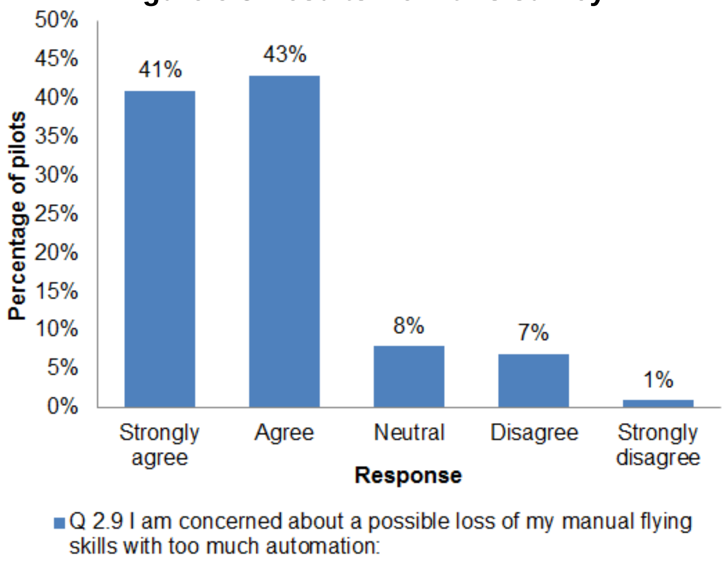


Figure 5.3 Results from this survey.



Gillen's study (Gillen, 2008) indicated that 80% of those pilots surveyed agreed that their manual flying skills had declined over time. This compares similarly to this study in which 72% of the pilot population agreed (Q2.15). This is a much greater proportion when compared to the 43% of pilots in the BASI (1996) survey. Again, this may be due to a greater percentage of automated aircraft now being in service and also there has been a longer time period for pilots to have noticed a decline in their manual flying skills in the last eighteen years.

Figure 5.4 Results from BASI 1996 survey.

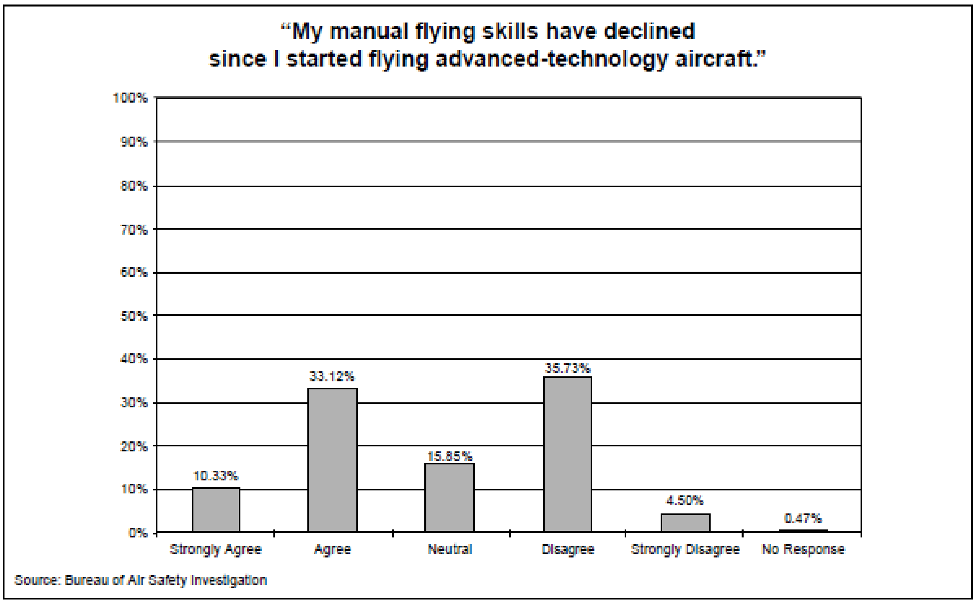
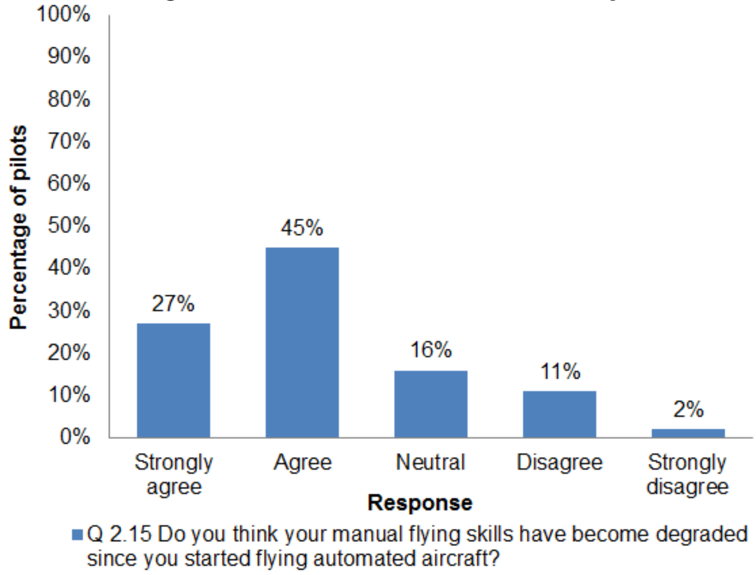


Figure 5.5 Results from this survey.



When responding to the question, "I like to hand fly part of every flight to keep my skills up" (Q2.9), the results are generally similar to the studies carried out by Wiener (1989) and BASI (1996), as can be seen in figures 5.6, 5.7 and 5.8. This shows that the majority of pilots still like to hand fly if they get the chance. However, these chances may now become limited due to various performance shaping factors, such as operator automation policy. These various factors will be discussed further in this section.

Figure 5.6 Results from Wiener (1989) survey (Source: Wiener, 1989).

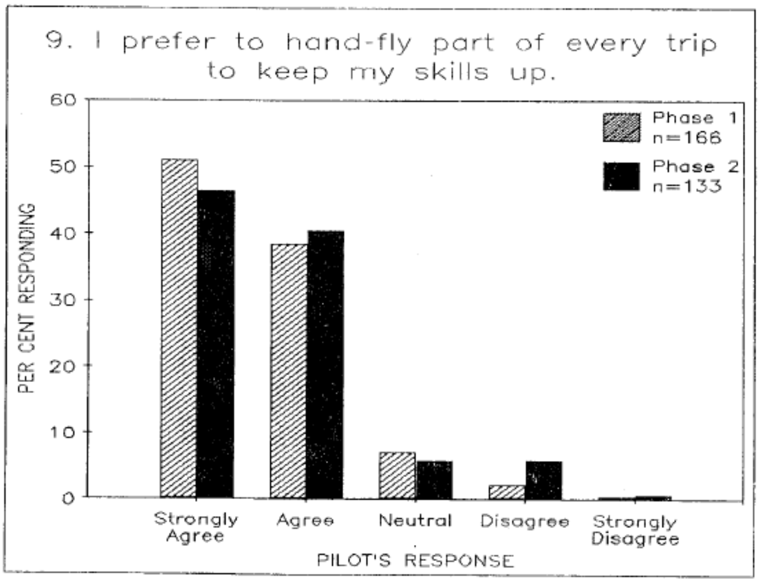


Figure 5.7 Results from BASI (1996) survey.

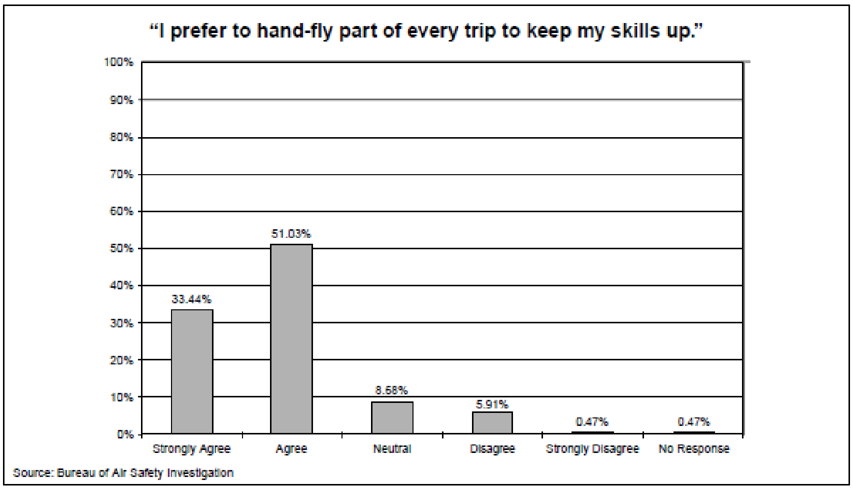
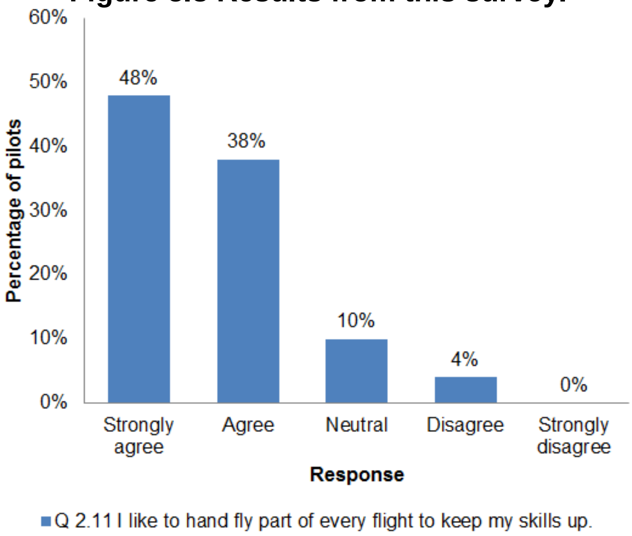


Figure 5.8 Results from this survey.



The results from the EASA survey, regarding the question, "is it necessary to improve basic airmanship and manual flying skills of pilots" (Q2.20), were very similarly distributed (see figure 5.9 and table 4.16).

Figure 5.9 Results from EASA survey (2012b) (Source: EASA)

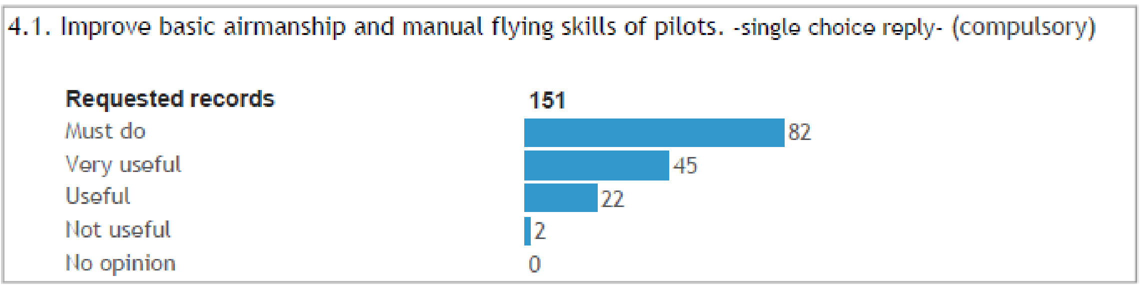


Table 4.16 (from page 35) Pilot responses when asked if they think it is necessary to improve basic airmanship and manual flying skills of pilots (Q2.20).

#	Answer		Response	%
1	Strongly agree		527	60%
2	Agree		313	35%
3	Neutral		34	4%
4	Disagree		8	1%
5	Strongly disagree		1	0%
	Total		883	100%

5.3 How often do pilots fly manually?

It is accepted that there are many variables within the pilot population, such as type of operation, different aircraft and operator policy. The data gathered is intended as an overview of the global “trend”. The histogram output and plot (seen in chapter 4, figure 4.3) show the majority of pilots’ responses are concentrated around the “sometimes” and “very occasionally” answers.

It can be seen there is consistency between the results where pilots observe their colleagues when compared to their own responses. Overall nearly half of all the pilots appear to be conducting manual flying on a “very occasionally” or “never” basis. These pilots will likely see their level of manual flying skill decline over time unless measures are taken to prevent this.

When compared by sub-groups, the most significant differences were noticed between the long and short-haul pilots groups, corporate/business jet pilots and the Captains/First Officers groups. The short-haul pilots did more manual flying than long-haul, unsurprising given that they will have more flights/opportunities in which to fly manually. Also the group of Boeing 737 pilots showed they did more manual flying than the Airbus A320 series pilots. However this is most likely due to differences in their respective operators’ automation policies, rather than differences due to aircraft design factors. The group of Captains did more manual flying, it is suggested that this is due to them having greater confidence in their own manual flying skills as a result of their greater experience. Also the results show that more First Officers (60%) had been dissuaded from flying manually at some point because their colleague on the flight deck felt uncomfortable, versus 29% of the Captains (Q4.8). As Captains are ultimately responsible for the safe operation of their aircraft, it may be that some are reluctant to let their First Officers fly manually due to the reduced chance of an ‘incident’ or exceedance if the aircraft is flown with the automation.

There were no significant differences between initial flying training background, age or number of flying hours.

5.4 Factors leading to reluctance to practice manual flight

Part of the survey (Q3.10) asked pilots to indicate from a list of twelve statements, what they thought the main reason would be that may make pilots reluctant to practice manual flight. The results showed five main areas:

- They don't want to risk triggering a FDM event. 18%
- It is easier to let the automatics do the work. 17%
- They are feeling fatigued. 14%
- They will have more monitoring capacity/SA. 14%
- They are not sure what their skills will look like. 9%

It is realised that a combination of factors may dissuade pilots and not just one single factor, for example a pilot may feel he is more likely to trigger a FDM event if he is feeling tired or fatigued. With FDM coming out as the most frequent factor, it was found that pilots from operators based in the Middle East and South America were those most likely to be dissuaded from flying manually. When the pilots were asked whether they agreed or not with the statements, the statement, "it is easier to let the automatics do the work", actually had the highest number of pilots in agreement. Are pilots lazy? Pilots are just as likely to exhibit the same behaviour as any other group of persons when it comes to wanting the greatest outcome for the least amount of effort (Zipf, 1949).

5.5 Situations where manual flight is required

The vast majority of pilots have at some point been faced with situations where manual flight has been necessary, be it due to aircraft system failures (73%) or external factors (83%). Whilst the results showed pilots who had more flying hours have experienced more failures; this is expected due to the increased probability of failures over a greater time span. Nevertheless, 57% of those pilots in the youngest category (aged 18 to 25) have been faced with flight guidance or autopilot failure, and 47% with an in-flight aircraft system or equipment failure that required them to fly the aircraft manually. It can reasonably be assumed that as this group accumulates hours, then the probability of situations occurring which require manual flight will increase.

81% of the pilots had also found the aircraft to be in an automated mode which was not expected and then resolved the situation by reverting to manual flight (Q4.2). Therefore pilots still need the ability to be able to fly manually in today's operating environment.

When examined by region, those pilots based in North America had experienced the greatest number of situations requiring manual flight due to failure of an autopilot or flight guidance system (Figure 4.6, Q2.2, Q2.5 and Q2.6). When looking at the average age of airline fleets across different regions, North American operators have a relatively older average fleet age (the majority between eleven and fourteen years old, according to the airfleets.com website).

Whereas Middle Eastern and Asian Carriers' fleets are somewhat younger, with an average age of five years and seven years respectively. With the rapid growth of airlines in these regions over the last decade, there have been many more new aircraft delivered, hence the lower average fleet age. With these newer aircraft it is probable that there is an element of increased reliability. There is also a greater proportion of relatively older aircraft types such the Boeing 757/767 and MD80 series in service in North America, when compared to the Middle East for example.

The life cycle of current in service aircraft designs can be a considerable length of time. Fly-by-wire aircraft such as the Airbus A320 have now been in service for over 25 years. These types are still in production and will be in service for several more decades. Newer designs may be based around the architecture of these types, so it is likely that the problems/failures of equipment (which may require manual flight) will be similar in frequency and category when compared with the current in-service aircraft. External events requiring manual flight will be independent of the age of the aircraft and the experience of the crew.

5.6 Fatigue

Fatigue is a real threat affecting the entire industry, and not just with regard to manual flying skills. That 97% of the pilots indicated that they noticed the performance of a colleague on the flight deck be affected by tiredness or fatigue, is undoubtedly significant (Q4.3).

Two thirds of pilots agreed that their schedules are generally just too busy so that pilots may be too tired to practice manual flying (Q4.4). Further results (Q3.9 statement #1) also support this finding, along with fatigue/tiredness ranking 3rd in the overall list of reasons why pilots may be reluctant to practice manual flight (Q3.10).

When comparing the group of long-haul pilots against short-haul, the percentage was identical in each case. Traditionally the long-haul pilot may have been viewed as more likely to be tired or fatigued, having experiencing multiple time zone changes and possibly large periods of under-stimulation/boredom. After being "awake" for maybe eighteen hours, it is easy to recognise that a pilot will not be at their peak performance and it is natural that they may wish to rely on the automation to complete their flight safely. The moral/legal implications of "practicing" manual flying at the end of a long-haul flight would quickly come under scrutiny in the event of an incident. Nevertheless, it is fairly reasonable to expect a pilot to have the skills necessary to fly an approach and landing safely should the automation fail. It is accepted that there may be some increase in workload, but for a competent crew in regular manual flying practice, this extra workload should be easily manageable. It is highly probable that the crews who are not in regular manual flying practice would find the extra workload much greater.

Short-haul pilots may often be subject to duties which involve frequent sequential early starts and/or late finishes. When combined with multiple sector days coupled with very short turnaround times, this group will experience greater instances of much higher workload situations compared to the long-haul group.

62% of the short-haul group agreed they had at some point been so tired or fatigued that they felt they could not fly the aircraft safely without automation, versus 59% of the long-haul group (Q4.5). These results show that fatigue is not solely a long-haul issue.

The thematic analysis of the pilots' additional comments provided further insight (see figure 5.10).

Figure 5.10 Comments from pilots regarding fatigue.

"The biggest issue is with long haul flights is we are excessively fatigued at the other end. If something were to happen, the thoughts are liability. Should we be "practicing" with passengers on board?"

"Majority of pilots are too reluctant to fly manually on an approach mainly due to lack of confidence in their abilities to do so and thereby becoming overwhelmed - in part due to loss of proper scanning technique (due to lack of practicing manual approaches) and/or fatigue."

"Where I currently work, I am constantly tired and occasionally fatigued due to excessive hours and poor rostering. This in addition to a very punitive FDM system means I consider the risk of manual flight during normal line flying too great - perhaps not safety wise but certainly career wise."

"The main problem is roster related recurrent fatigue. It temporary decreases vigilance and skills. Flying visual approaches without automations on the last sector of 11 plus hours day would be a potential additional threat from my point of view."

"Pilots worldwide are being asked to do more and more for less and less. Fatigue is by far the biggest problem, with some ULR fights being 16 plus…"

"The whole crew are tired at the end of a long flight (10-13hrs) and are (quite rightly) reluctant to increase the workload by manual flight."

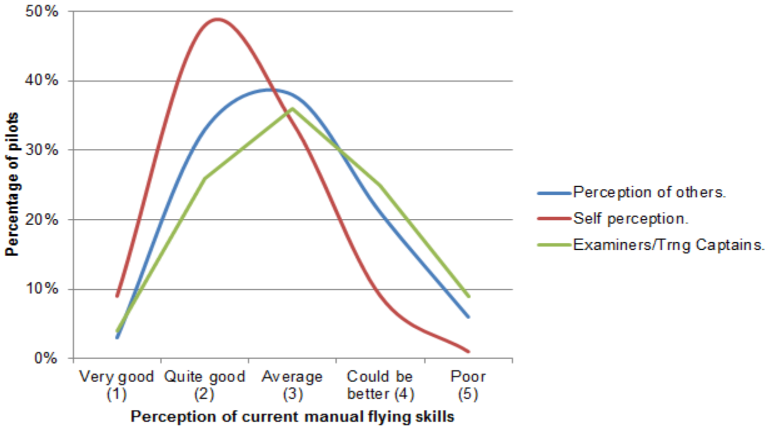
"How many workers will perform at their best at the end of their shift - let alone a 13 hour flight when you have been at work for at least 14 hours and awake for possibly considerably more? Manual flight cannot be 'practiced' at this stage."

"I realized that some pilots I have flown with avoid a manual flight due to a high workload for them when they are a pilot monitoring, and because our flight schedules are so fatiguing".

Anecdotal evidence indicates that many of todays' operators appear to treat Flight Time Limitations as "targets" rather than "limits." Operators try to get as much productivity as possible from their crews to keep costs as low as possible in order to remain "competitive." Latent conditions such as these cannot be conducive to maintaining an effective level of human performance with regards to flight safety.

5.7 Pilot perceptions of current manual flying skills

Figure 5.11 Comparison of perception of current manual flying skills (elf-perception and perception of others, with Training Captains' perception of others).



When asked how they perceived their fellow pilots' manual flying skills (Q2.16), the distribution was seen to be normally distributed around a point between "average" and "quite good," with a mean score of 2.92 on the five point Likert scale. The pilots' self-perception (Q2.19) showed them to rate their own manual flying skills somewhat better with a mean score of 2.45.

There is most likely an element of subjectivity involved here leading to a slight bias. It is probably a naturalistic human tendency to assess oneself favourably against others, and harder to objectively address one's perceived shortcomings.

The "perception of others" when taken from the point of view of the pilots in the survey who are Examiners/Instructors/Training Captains, gave a normal distribution around "average" with a mean score of 3.08. This is the professional group, who are more likely to be trained to assess people objectively. The distribution of their perceptions is closer to the "perception of others" from the main group, which may add credence to the results.

With the manual flying skills being grouped around "average", this is entirely normal as in any normal population most people should be "average," with some people's performance being above average and some below. It is difficult to rate manual flying skills as there is no set scale against which to judge them. Whilst there are defined limits for acceptable deviations of parameters such as airspeed, altitude and heading defined by the regulators for testing purposes;

pilots may use a number of variables in their assessment such as accuracy, control technique (smoothness) or ease of apparent effort.

It is encouraging to note that the pilot group as a whole recognises that their manual flying skills will decline if they are not practiced (Q2.10 and Q3.14). A large proportion (69%) feel that their manual flying skills have deteriorated since they started flying automated aircraft (Q3.12). Some 68 pilots (8%) indicated that they thought their manual flying skills had improved. This compares to Ebbatson's (2009) study where 7% of pilot thought their skills had improved and 77% thought theirs had deteriorated.

When examining this group of 68 pilots, it was found that 96% of these pilots were from a civilian training background, 89% were less than 45 years old, there was an even distribution amongst flying hours, 69% were co-pilots and 78% were based in Europe (including the United Kingdom/Ireland). It is possible that these pilots are noticing an improvement in their flying skills simply because they have done more flying, and/or work for operators who encourage these skills to be maintained.

5.8 Training

It seems evident that the majority of pilots had practiced manual flying in the real aircraft prior to a simulator check (Q3.3) and a similar number had observed colleagues doing the same (Q2.13). This does at first glance seem questionable: using the aircraft to train for the simulator? After all the purpose of the simulator should be a tool used to help with training for the aircraft. However, given that a pilot's performance is assessed several times per year, it is wholly understandable that they would want to perform as well as possible in the simulator; particularly if their job and even career may depend on it. A sub-standard simulator performance will be recorded on the pilot's training records permanently and may have consequences, such as re-training required, promotion aspects, or even dismissal in some cases.

It is notable that 37% of the pilots reported that their operator's recurrent training schedule did not allow them sufficient time to practice manual flying in the flight simulator (Q3.2). Coupled with later responses (Q3.4), there does not appear to be enough training occurring for manual flight operations. A significant proportion of pilots (76%) also considered they would like more time available in the simulator to practice manual flying. However, 85% of the pilots have received simulator training specifically for upset recovery (in the last 36 months). This high proportion is hopefully as a result of recommendations from accident reports, such as the report in to the accident of AF447 in 2009 (BEA, 2012b).

The majority of pilots also agreed that modern training is too much of a scripted "box-ticking" exercise (Q3.5). Interestingly, when the results were looked at by region, the West European and United Kingdom based pilots were less in agreement than the other regions. The increasing adoption of new training philosophies such as EBT and ATQP amongst these regions may be a contributing factor. The FAA's AQP programme is somewhat similar, and with ICAO (2013) providing EBT guidance, hopefully future training in all regions will become more type-specific and less of a "box-ticking" exercise.

Training visual approaches or circling approaches in a full flight simulator may have certain limitations, due to restrictions/cut off points on the projected visual display. There is also the issue of simulator fidelity versus the aircraft. Whilst simulators are extremely useful training tools, they may not be able to wholly reproduce the sensations of flight, such as accelerations and the subtle visual clues that are necessary. A simulator's generic flight model may be based on manufacturer's flight test data from one individual airframe, which may feel different when compared to individual aircraft. The flight model will not be able to accurately simulate aircraft behaviour far beyond the stall, as in most cases there is very little or no flight test data obtained from this part of the flight envelope. In addition, the role of simulators in upset recovery training maybe limited due to the lack of physical feedback (such as "g" force) that will be experienced in a real aircraft.

Where a simulator can be useful with regards to training manual flight, is in the development of a pilot's flight instrument "scan". In conjunction with an eye-tracking system, one United Kingdom operator (Thomson Airways) established that many pilots were employing random and haphazard instrument scanning "techniques", many of which ignored critical parameters on flight instruments for a considerable amount of time (Flight International, 2013). Methods such as eye-tracking can assist in re-training pilots and can also be very effective in the development of a pilot's monitoring skills.

Training programmes are generally focused on how to fly "with" automation and not how to fly "without" it. Airbus at least, seem to recognise this and state they are "going back to basics" with training for the A350. That is, trainees will learn how to handle the aeroplane first, before automation is introduced later on. They also plan -apply this philosophy to their existing aircraft programmes as well.

The majority of pilots (82%) agreed that manually flying the aircraft without flight director guidance (Q2.21) would be more beneficial than hand flying but following a flight director. The cognitive demands on solely following a flight director will be much less than flying "raw data", so it is encouraging to see that pilots are aware of the training benefit. Whether they are actually allowed to switch off the flight directors may depend on who they fly for.

Aircraft operators' training budgets will often be under commercial pressure and in order to minimize the resources required, training programmes will be designed around the minimum standard required by their regulatory authority. Simulator time may be seen as a precious commodity; however some operators do now provide dedicated manual handling simulator sessions. This shows good intent, but when a major carrier schedules two thirty minute sessions per year, or one sixty minute session; is this really enough to address the issue and allow pilots to regain or maintain manual flying skills? A number of pilots provided comments (with mixed opinions) on these simulator sessions during the survey (see figures 5.12 and 5.13):

Figure 5.12 Comments (negative) from pilots regarding training.

"My company has manual flying exercises in the sim, however each segment is just completed once and therefore there is no opportunity for improvement (particularly new FO's). There should be at least three attempts at each sequence allocated to allow the chance to improve, and if the first attempt is a high standard more challenging scenarios introduced. Currently a candidate can complete a task to a minimum standard, be deemed proficient and then sent on their way. There should be an impetus to improve their skills not simply tick a box."

"…manual flying in the sim, yes we have it but such exercises last a maximum of 10 minutes and I feel it's just there to keep the aviation authorities happy and to cover the airlines back. For example, if an accident were to occur due to, or the situation was made worse by, poor manual handling skills the airline can turn around and blame the pilot as they have provided manual flight training."

"Whilst practicing manual flying skills in the simulator is a good idea, my company has a very punitive attitude towards simulator training. Basically, if the training exercise is successful, it's a pass. If there are any hiccups (even in TRAINING Modules) then it is a bare pass or fail with subsequent negative training reports and possible visit to the Fleet Office. As such, no pilot in the entire company ever accepts the opportunity to do any more than the minimum required in the simulator. A poorly executed visual approach in the simulator during spare time could end up with a visit to the Fleet Office. The same attitude applies to hand flying the real aircraft. Why risk a slightly untidy approach with subsequent FDM when it means your job is on the line. Yes, [company name] does fire people for this sort of thing."

Several pilots mentioned that a "non-jeopardy" hour of simulator training would be most beneficial. There was at least one positive comment:

Figure 5.13 Comments (positive) from pilots regarding training.

"Our airline has gone back to embracing "first principals" as a recurrent training theme. So far very well received. Lots of manual flight training in three -4 hour sim periods, both low level and high altitude air work. Day three, a check day or LOE as we call it under AQP Training."

The ECA's paper "Pilot Training Compass" (2013) puts forward many valid points for the development of future training programmes, emphasising the need for basic flying skills and the need to be "fluent" in them rather than just "proficient."

5.9 Operator policy

An operator's policy towards automation use will have a profound impact towards the ability for crews to maintain their manual flying skills. It may be that a pilot wishes to fly manually but their company discourages it, via a "make use of automation at all times" type policy, as was found in 20% of the respondents answers (Q2.14). Just over half the pilots considered that their operators' policies were matched to "use an appropriate level of automation as required." The number of operators where manual flying is "actively encouraged" appears to be in the minority, with only 11% of pilots indicating so.

One respondent to the survey highlighted that the automation philosophy may differ between fleets within an airline, on the company's Airbus fleet the philosophy was *"fly managed to avoid damage"* and on the Boeing fleet manual flying was encouraged. The 'managed' term refers to the level of automation which controls the aircraft flight path via the Flight Management Guidance System, as opposed to the pilot 'selected' functions). There were a number of differing responses during the survey regarding operators' automation policies, a sample of which can be seen below:

Figure 5.14 Comments from pilots regarding operators' automation policies.

"My operator does not allow manual flying above 10,000 feet nor use of manual thrust. Some approaches (esp. RNP AR) require full use of the autopilot as standard operating procedure. At present, a manually flown go around is the one hand flown manoeuvre that is the weakest within my company. This is largely down to the fact that it is flown hardly ever."

"I worked in several airlines, and some of them it was prohibited to disconnect auto thrust, after one year on that airline I felt a big loss of confidence and my manual flying performance degraded. "

"I am happy that my operator allows us to do manual flying/Manual thrust. In my opinion it is very important to keep up those skills. As far as I know, some operators are very restrictive and want pilots to use automatics at almost all times. In that case I see a big risk in losing manual flying skills".

"One major Middle Eastern carrier specifically mandates the FD must never be switched off during line operations."

"I'm fortunate to operate in an airline where manual flying is encouraged whenever appropriate. It is relatively rare for me to use the automatics to fly approaches. However, I believe that this is quite unusual in the industry. Manual flying skills and airmanship in general seem to be less and less valued by training departments, with maximum use of automation at all times…"

"Airlines policy concerning use of automation has to change as over reliance on automation has been contributing factors in accidents, and this will increase in the future."

Figure 5.14 (continued).

> *"Training manual flying alone does not help if fleet chief strongly recommends only fully automated approaches and absolutely no visual/no ap/at/fd approaches"*
>
> *"In my airline operation visual approaches are sometimes possible, however the pilots are very reluctant to fly them – primarily due to their perceived low manual handling skills (a lack of recency and confidence) and the "threat" of making a mistake/error and/or poor handling and then being invited up to "have a chat" with management…"*
>
> *"My company's policy does not allow us to fly with AP/AT off..."*
>
> *"I feel operator policy is the primary culprit here. Too many times operators have dissuaded manual flying by insisting on implementing procedures for 'safety'. Additionally even if something is not written in black and white in the books, the attitudes of the flight ops department filter their way down through the ranks and become accepted as fact. Examples of both bad policy and poor attitude from management include: 1. Flight director required "on" for all flights regardless of weather. 2. "Strongly Suggesting" crews not accept visual approaches. 3. Older flight crew who have lost their edge demanding that automatics be left in even in benign flight conditions."*
>
> *"Our airline promotes a culture of hand-flying above and below 10000', or higher if desired and conditions allow."*
>
> *"Our operator uses manual flying as a trap at times in check rides in Simulator. Unfortunately if they see you relying too much on automation they fail it and then load you up, often ending in failure. It becomes a negative training exercise (often to failure)."*

With 43% of the pilots feeling that their operator's automation policy is having a negative effect on maintaining manual flying skills (Q2.17), this does outweigh the 25% those who feel the opposite.

5.10 Monitoring

Just over half the pilots had received guidance from their operator with regards to maintaining manual flying skills (Q2.3). A similar proportion had received guidance for maintaining or improving monitoring skills (Q5.8). The region where most pilots had received guidance was Asia, with 68% of the pilots indicating so. Conversely only 35% of those pilots based in the Middle East had received operator guidance.

The results showed that 97% of the pilots thought monitoring skills are equally as important as good manual flying skills (Q5.7). Indeed they are, as proper monitoring (and intervention) could have prevented many of the relatively recent loss of control accidents which involved low airspeed situations, such as the Asiana Boeing 777 in San Francisco, the Turkish Airlines Boeing 737 crash in Amsterdam and the Colgan Q400 in Buffalo, New York.

The survey showed that respondents perceived their fellow pilots monitoring skills as predominantly “good” (Q5.9). Measuring or assessing monitoring can be challenging, as generally the first indication that an individual may be not monitoring correctly is when the handling pilot makes an error or deviation that is not spotted, but there are other metrics to consider such as reaction times. The previously mentioned eye-tracking research in simulators may prove to be an effective tool in this domain.

Several respondents indicated that more manual flying would improve monitoring skills. A further number indicated that manual flying would increase the “pilot monitoring” workload. This does seem somewhat strange given that the pilot monitoring is there to “monitor”. Admittedly there is more to it than just watching the flight instruments: hazards, systems, weather, terrain, checklists and other traffic all needs monitoring.

The survey asked if pilots (acting in the role of Pilot Monitoring), *“would you feel the workload in the flight deck would be increased to an unacceptable level if the ‘Pilot Flying/Handling Pilot’ were to fly a descent and approach manually without the use of autopilots or flight directors?*” (Q4.1). Two thirds (66%) of the pilots disagreed with this, whilst just over a fifth (21%) agreed, with the remainder neutral. So it would seem that there is an element that is in the minority, which considers manual flying to be unacceptable with regards to PM/PNF workload.

5.11 Flight Data Monitoring

With FDM now mandatory for aircraft weighing more than 27,000kgs, it is a vital tool in being able to identify hazards related to aircraft operation. Hazards may show up as singular occurrences or as a pattern of long term events.

Some 34% of the pilots (who flew FDM equipped aircraft) indicated that they had at some point, been dissuaded from flying manually because they were mindful that they may trigger a FDM event. Whilst this means 66% of pilots were not dissuaded, it still equates to one pilot in every three that is. Provided an aircraft is operated within its limits, it is likely that very few FDM events should be triggered. There will inevitably be some, even when the flight path is under automatic control, possibly due to events such as an over speed caused by mountain wave activity. So why should FDM dissuade pilots from flying manually? During the thematic analysis part of the survey, numerous FDM/FDAP/FOQA related comments were evident. A selection of which can be in figure 5.15.

Figure 5.15 Pilots' comments regarding FDM.

"I am also of the opinion that FDAP plays a major role in the reluctance of some pilots to fly the aircraft manually. We have had demotions to lower rank, and dismissals at our airline due to FDAP events (they were relatively serious though). We have also had a ban (via a notice to crew) on accepting and flying visual approaches."

"FDAP has greatly increased pilot's paranoia, and that, coupled with the amount of night flying, leads to the autopilot doing most of the work."

"In the airline I fly for, a large [region] based carrier, fear of retribution from management following an infraction picked up by the flight data analysis programme, is the greatest factor preventing pilots from manually flying the aircraft…"

"The use of FOQA, complacency, and lack of manual flying culture has made pilots more afraid and lazy and airlines more confident on good FOQA numbers that many times hide a reality of low proficiency on manual flying and monitoring."

"The use of automation is driven by the airline culture. [Airline name] safety culture is measured by the FDAP program. Therefore the entire safety push from flight ops management is to minimize FDAPs. The increase in hand flying (especially on the descent and visual approaches) would probably increase FDAPs. Therefore, hand flying is not particularly encouraged. I think if you compared operations with a similar operator (e.g. [Company name]) who put less emphasis on the FDAP program you would probably find their FDAPs somewhat higher but their pilots would have a greater comfort in manual flying situations like visual approaches and hand flying on the descent."

"As a Checker/Trainer, I have seen a significant decrease in manual flying skills. IMHO this is due predominately because: 1/ we are a long medium/haul airline. 2/ fatigue due to schedules, back of the clock flying. 3/ my feeling is that our Company would rather not see us manually fly above 5000' on departure, and not until configured on approach! 4/ It is felt among crews that the risk of being called up to explain why the FDs were off and you triggered an FDAP, increases beyond a suitable beneficial return in skills improvement. 5/ Due to all of the above less manual flight is practiced and therefore everyone is less current, it follows the risks increase and crew are less willing to practice manual flight/raw data flying. I strongly feel that manual flying skills need to be maintained for reasons already highlighted, but it also increases pilot monitoring skills…"

"I can say with some certainty that most pilots are afraid to fly raw data. Primarily because they can't do it for an entire approach. Also because they don't want to trigger FDM and make a fool of themselves."

"My general feeling after only 2000hrs on jet aircraft is that the OFDM/FOQA is interpreted more as a threat than an aid".

It would appear that a number of operators are using the system in a punitive nature, which is not in keeping with the “spirit” of FDM. When examined by region, the Middle Eastern and South American based pilots showed the highest proportion of pilots who had been dissuaded from flying manually due to FDM related issues.

A “just culture” is essential as part of an overall safety culture within an organisation. It is possible that in these regions, there are also “national” cultural issues at stake.

It is noteworthy that in the results that these two regions also had the lowest proportion of pilots who had received guidance on maintaining flying skills from their operators.

5.12 Culture/Region

It is very difficult to evaluate pilots by country or region, for example many European and American pilots fly for operators in Asia and the Middle East. Even cultures within one region such as Europe, may differ significantly: pilots from Scandinavia may respond differently to those from Mediterranean countries. However the culture of the operators or regulatory authorities may be more closely aligned and this could influence how the pilots respond.

It was evident from the comparison by region, that the Middle Eastern and South American based pilots had strong concerns regarding manual flying. The respondents from these regions had the lowest percentage of pilots who practiced their manual flying skills (Q3.8) and who observed colleagues practicing manual flying skills (Q2.8). These two regions showed the highest percentage of pilots who thought their operator’s automation policy was having a negative effect on maintaining manual flying skills (Q2.17) and FDM dissuading them from flying manually (Q4.7).

Pilots based in North America appeared to have the fewest concerns out of all the regions with respect to manual flight. This region had the highest percentage of pilots who see colleagues practice manual flying skills, feel the most comfortable with flying “raw data” (Q2.7 & Q2.12) and flying visual approaches (Q4.11). They also had the lowest percentage of pilots who were dissuaded from flying manually due to FDM concerns (Q4.7); and also the lowest percentage who had been dissuaded from flying manually because their colleague on the flight deck felt uncomfortable (Q4.8).

The operational environment of flying in North America no doubt plays a role in this. Visual approaches at major airports are a common occurrence and there is a much larger general aviation background and military from which to select pilots. It is almost unheard of in North America for a low-hours (cadet) pilot to go from flying school straight into the cockpit of a medium or large jet transport aircraft, as happens in some other regions. Most pilots will have been flying instructors and/or worked for smaller commuter operators before joining the “major” operators and therefore will have had more opportunities to build up their level of manual flying ability.

5.13 Flight deck design issues

There was clear agreement that respondents thought angle of attack (AOA) should be displayed directly to the pilots on all public transport aircraft types (Q5.1).However, the number of military trained pilots who “strongly agreed” was greater than their civilian counterparts. This is most likely due to the fact that most military high performance aircraft types are fitted with some form of AOA display, so there is likely an element of bias or favouritism from pilots who have previously flown with AOA displayed.

Having AOA displayed to the crew may give them an idea as to how close the aircraft is to the stall and could possibly permit earlier recovery actions during low airspeed loss of control events. It could also be useful as a backup system in case there is a loss of airspeed information at low Mach numbers.

The AOA at which an aerofoil/wing will stall is not fixed, as it dependent on various factors such as Mach number and aircraft configuration (Palmer, 2013). The stall AOA of jet transport aircraft on any display would have to show something other than just arbitrary units. At high altitude the stalling AOA may be in the order of 3° to 5°, whereas on approach the value may around 15°.

The FAA is also starting to recognise the benefits of having AOA displayed. In July 2014, they released information for general aviation operators promoting the initiative to install AOA based systems to prevent loss of control accidents (FAA, 2014). Future versions of FAR 25/CS-25 will hopefully take this issue further.

There is the argument though, that given another display on the flight instruments, AOA is just another parameter that may go unmonitored by the crew. However, more manual flying would likely increase the pilot’s “scan” and with better instrument scanning, then pilots may be able to recognise deviations earlier.

There were slightly more pilots agreeing that there should be more audio and visual warnings from aircraft designers to alert of low airspeed situations (Q5.2). This indicates that current designs are generally perceived as being adequate. Again their awareness may have been raised due to recent accidents.

With regards to monitoring of airspeed, there was a slight preference towards the EFIS based system, when compared to the round dial/analogue system (Q5.3). There was a marked preference for the EFIS display in the younger pilot group when compared to the older group. This may be as a result of the older pilots having previously flown aircraft types with analogue/round dial type airspeed indicators, and also the younger pilot group having only ever flown EFIS type aircraft. So in each group, it is possibly a case of preferring what they are most familiar with.

It was also clear that 'trend vectors' on primary flight display instruments made manual flight a lot easier (Q5.4) and the majority were in agreement that it is beneficial practicing manual flight in aircraft fitted with full flight envelope protection with fly by wire/auto-trim (Q5.5).

It is proposed by the author, that the importance of airspeed monitoring should be the same whether an aircraft is equipped or not with an autothrust system. With the majority of aircraft fitted with such systems, there was a significant proportion of pilots (41%) who indicated less monitoring of airspeed is required (Q5.6). A much smaller proportion (14%) thought more monitoring is required. This illustrates that pilots are not monitoring equally and most are probably becoming overly reliant on automated systems. The number of recent low speed loss of control accidents also bears witness to this. In the event of a system failure where manual thrust/airspeed control is required, some pilots will subsequently find greater monitoring demands are required. With 11% of pilots indicating they had experienced a failure at some point of the autothrust system, it appears these are not particularly rare occurrences.

5.14 The view from across the cockpit

A number of pilots expressed comments regarding the difference between Captains and First Officers. Possibly due to a decline in their own flying skills, or fear of retribution in the event of a FDM occurrence, some Captains appear to be reluctant to let First Officers fly manually when asked. Conversely, some Captains try to encourage their First Officers to fly manually, but a lack of confidence or skills leads to some First Officers declining the opportunity. Some of the comments can be seen in figure 5.16:

Figure 5.16 Pilot's comments related to crew issues.

"I fear that captains have no trust in the manual flying skills of their co-pilots, so they usually decline, which in turn does not allow co-pilots to maintain their flying skills. This is a vicious cycle which is very hard to get out of in a large company."

"My F/O's watch the FMA panel when I hand fly instead of looking at the parameters and looking outside too...and if I disconnect the F/D they are lost because we cannot arm the LOC/APP modes... how will we capture the ILS? They often ask... "

"Some Captains are not letting fly manually whatever reason was. I even fly at home flight simulator it helps somehow keep my skills current."

Figure 5.16 (continued).

"As a captain I always encouraged co-pilots and even cruise relief pilots to fly manual as much as possible during descent approach, but also told them if you don't feel happy anytime switch on the AP, and when happy again revert to manual."

"Many of the First Officers and some Captains that I fly with are weak in their flying skills. They display poor skills probably because they never learned them in the first place, and were promoted to the positions they hold simply because of the demand for pilots. Many should be "failed" in their simulator sessions, yet the airline still passes them".

"Selection for pilots should be much better. If you pay enough you get a license. Many co-pilots are afraid to fly manual because of lack of training and lack of performance. This is dangerous. Good pilots are with the big airlines, ever age to below average by second rated airlines. Overall it's a miracle no more accidents happen."

"One obstacle that prevents co-pilots from practicing their manual flying skills during line flying is the marked reluctance of captains to permit such practice. This is primarily because many captains hide their own distaste or lack of self confidence in their own manual skills by denying their first officers the opportunity to keep their hand in especially with flight directors switched off. Excuses given by captains are invariably lame."

"I think a big problem is not a loss if skills but that they never were there. Many FOs I fly with are cadets with under 200 hours total. They have so little flying experience, such an automated aircraft us not ideal, in my opinion, as a first type. These guys rarely want to fly a visual let alone an ILS in IMC even with a high cloud base. I try to get them to fly visuals and good days but many say no. Some FOs recently failed command courses in my airline for poor handling. It is a worry."

"As a FO, one of the main concerns of not flying manually is not to upset the captains. Not all captains encourage manually flying even if the weather is nice and traffic is not busy."

"I am very disappointed to see that manual flying skills are slowly eroding, mainly due to the lack of practice, automation policy of airlines and the fear of displaying the (lack of) flying skills to your fellow pilot in the flight deck. Especially as an FO you don't have much liberty to do some manual flying when you feel the majority of captains are uncomfortable with it."

"The flying ability of low cadets at the moment is beyond poor. I do not feel that if alone in the cockpit and a failure evolved, they would not be able to cope. Even with the Autoflight system operative. It is increasing the workload on the Captains and distracting them from tasks".

Figure 5.16 (continued).

> *"Captains are very reluctant/scared to hand fly and even more concerned to let a First Officer to do it so. Practically no one ever hand flies."*
>
> *"I fly with many FOs who tell stories of other captains who are not comfortable with them hand flying, especially with Autothrust and FD off. "*
>
> *"…very rarely do First Officers that fly with me undertake any manual flight despite me offering the opportunity to them. I am a keen pilot, fly the Airbus manually fairly regularly and fly light aircraft and aerobatics so I tend to feel much more comfortable with manual flight. It's really no big deal when skills are practised! FOs tend to get into a lazy streak of not wanting to do it. But this is fostered by the majority of Captains not letting them do any manual flight in the first place. Therefore I think this endemic problem emanates from Captains. FOs are always told 'no' so they give up asking. I'm passionate about aviation and do my utmost to encourage FOs to have a go if they would like to and the environment/weather dictate it to be an acceptable thing to do."*

Clearly there is a growing problem. If First Officers are not flying manually, it is highly unlikely their manual flying skills will improve, and in all probability they will decline. So when those First Officers become Captains, they are likely to have a limited amount of manual flying skill, and be even less likely to encourage the next generation of First Officers to fly manually. A further downward trend in manual flying skill will be inevitable.

The full comparison between the group of Captains and First Officers showed differences in several areas which can be seen in Appendix A.4.

More Captains (27%) than First Officers (15%) felt the workload as "Pilot Not Flying" in the flight deck would be increased to an unacceptable level for normal operations, if the "Pilot Flying/Handling Pilot" were to fly a descent and approach manually without the use of autopilot or flight director. The Captains also felt more comfortable flying raw data, visual approaches and were less likely to be dissuaded from flying manually because of FDM.

5.15 Comparisons between groups.

A great deal of information was available from the comparisons between the various sub-groups. It is beyond the scope of this discussion to explore every possible comparison. The aim being to discuss the most prominent findings.

When comparing pilots from a civil training background to those from the military, there were few very areas in which they differed with regards to the survey responses. There were slightly more military pilots than civilian, who thought their manual flying skills had declined since they started flying automated aircraft. This may be due to the fact that military flying operations generally involve more manual flying in tasks, such as formation flying, low level operations and air-to-air refuelling. Hence it is highly likely that a military pilot will (on average) have a higher level of manual flying ability than their civilian counterparts. Therefore they will notice a greater decline in these skills if they are not practiced, as they have more skills to “lose”. These fine motor skills are comprehensively trained in order to reach the required high standards, and the training ‘system’ may be regarded as more selective and arduous than the civilian flying training system. This is not to say that one is inferior to the other, as the demands on the “end product” of each system are vastly different.

Nineteen MPL trained pilots completed the survey. Due to the small sample size they were not compared to any other group. The small sample size also most likely reflects the current proportion of MPL pilots currently engaged in commercial operations. The entire MPL group did indicate that they feel their manual flying skills will decrease over time if they do not practice them (Q2.10). 84% of the group indicated they felt that their manual flying skills have deteriorated since they started flying automated aircraft (Q3.12), and 37% had at some point been dissuaded from flying manually because their colleague on the flight deck felt uncomfortable (Q4.8). The same proportion had also been dissuaded from flying manually because they were mindful that they may trigger a FDM event (Q4.7). It appears that this group are not in the best positon to be able to develop their manual flying skills.

The high-hours pilot group also indicated they were comfortable flying a visual approach with 68% indicating so, compared to 45% of the low-hour group. These results suggest that confidence is lower in the low-hour group (when viewed from both sides) with regards to manual flying skills.

A greater number of long-haul pilots (81%) thought that their manual flying skills have become degraded since they started flying automated aircraft (Q2.12 and Q3.12), when compared to the short-haul pilots (62%). Interestingly, 10% more long-haul pilots felt more comfortable flying “raw data” than their short-haul colleagues. However, it is suggested that the general higher experience of long-haul pilots may account for this and it is likely the majority will have flown short-haul operations at some point in their careers.

The corporate/business aviation pilots appeared to have less issues relating to manual flight and practiced it more often. Fewer had noticed degradation in their skills and there was a greater proportion of pilots who were very comfortable flying raw data and visual approaches. Business jets may fly to a much more varied set of destinations and may make use of smaller airports (which have limited landing/navigation aids) when compared to the airline industry. This will require a higher amount of manual flying. Coupled with the typical owner of a business aircraft who may be a high worth individual or organisation; these owners will generally expect their pilots to have a very high level of experience/ability in order to ensure their safety in an emergency. The same ability may not yet be present in a pilot who starts flying with 200 hours total time in a low cost airline for example.

The comparisons between the predominant aircraft types in the survey revealed few surprises and it is not the intention to create an “Airbus versus Boeing” discussion. For the medium jet transports (A320 series and Boeing 737) the A320 pilots felt slightly less comfortable conducting a flight of one hour duration with the autoflight and/or autothrust system inoperative (Q2.7). The Boeing pilots showed a greater percentage (53%) who perceive their colleagues’ manual flying skills to be currently “quite good or very good” when compared to the Airbus group (35%). The Airbus group had a higher percentage of pilots who *never* or *rarely* fly manually (Q3.8) and they also felt that with autothrust less monitoring of their airspeed is required (Q5.6).

The large jet transport aircraft groups (Boeing 777 and Airbus A330) results were more closely matched, with the exception that 93% of the A330 pilots agreed there is benefit in practicing manual flight in aircraft having full flight envelope protection with fly by wire/auto-trim when compared to 68% of the Boeing 777 pilots (Q5.5). It is conceivable that the 2009 Airbus A330/AF447 accident may have shaped the pilots’ responses in this respect.

6. Conclusion

6.1 Summary

The results of the main survey indicate there is a continued need for manual flying skills to be maintained. The majority of pilots have experienced situations, both technical and non-technical, where manual flight became necessary.

Nearly all pilots are aware that their manual flying skills will deteriorate over time if they are not practiced and many pilots indicated that their skills have become degraded since they started flying automated aircraft.

A number of issues have been identified that may be acting as barriers thereby preventing pilots from practicing manual flying skill. These include fear of triggering a Flight Data Monitoring event, insufficient training opportunities, fatigue and restrictive operators' automation policies.

Several differences in the amount of manual flying between the pilot sub-groups were identified. Whilst some of the results may not be surprising, they do highlight that pilots now entering the industry are facing an operating environment where it will likely be very difficult for them to develop or maintain their existing level of manual flying skills. Hopefully it shows there is now some evidence to support anecdotal concerns that the industry is faced with a real threat in relation to the maintenance of manual flying skills. Unless meaningful action is taken by operators and regulators, then it is predicted that there will be an increased probability of further accidents and incidents, resulting from overuse of automation combined with a lack of timely intervention when manual flying may have been appropriate.

The issue of confidence (or lack of it) to practice manual flying appeared frequently in the comments provided by the pilots. One pilot raised a very good point that, "maintaining manual handling skills are very important, not just as a backup for when the automation fails, but they allow a pilot to confidently operate their aircraft. The confidence in ones abilities will allow them to easily maintain situational awareness, make accurate decisions and reduce task saturation. Lack of confidence will promote 'second guessing'" of one's decisions and reduce mental capacity for the operation of the aircraft."

6.2 Suggested future research

Whilst a variety of important issues have been highlighted during this study, it was only possible to give a summary of them. It may be beneficial to examine the individual issues in greater depth, such as cultural/regional differences in the application of Flight Data Monitoring, as this may point further to the underlying factors.

As this study is effectively a “snapshot” of the pilots’ current perceptions and views on manual flying, it may be worth conducting a similar study at some point in the future to see how pilots’ views and the industry have changed.

Also with automation now becoming a standard feature in many multi-pilot helicopters and following a recent automation-related helicopter accident in the North Sea, a study of helicopter pilots may prove to be of benefit.

6.3 How to improve manual flying skills?

The results show that the majority of pilots think a less restrictive operator automation policy and more simulator training would be the most effective methods to maintain or improve manual flying skills. For this to become effective, aircraft operators will need to find the judicious balance between risk and cost. An increase in the mandatory requirements in simulator training may also be beneficial; The FAA are beginning to encourage simulator training without full use of automation (FAA, 2013c) and hopefully steps such as these will become more common throughout the industry.

There are regulatory ‘recency’ requirements regarding minimum numbers of take-offs and landings in order to remain ‘ ‘current’. Some operators have their pilots keep a “landing card” with their licences to record and keep track of the number of autolands. It is suggested that a similar system of recording a specified number of manually flown approaches could be introduced with little effort and expense.

Whilst this study has predominantly highlighted the decline in manual skills, it must be mentioned that a number of pilots do actively maintain their manual flying skills, be it through flying manually when appropriate, or by flying light aircraft, aerobatics or gliders in their free time.

Manual flying ability is just part of the knowledge, skills and attitudes that a pilot should possess in order to operate their aircraft in a safe, effective and efficient manner. These qualities may also be known as “airmanship”.

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Appendix A

Where there were noticeable differences between groups in responses (~10% in each question), the individual question was examined further to establish if the difference was statistically significant.

A "differences in proportion test" was performed between group results in order to determine if the results were significant within a 95% confidence value. This test is only valid if both samples satisfy the standard binomial requirement, that being n*p and n(1-p) must both be equal to or greater than 5, n=sample size and p=percentage. Where the requirement was not satisfied in some cases, a chi-squared test was performed using the actual values obtained in place of the percentage values.

The following tables list the questions which had notable differences between each group.

A.1 Comparisons by age group

Sub-group 1: Pilots aged 46 to 65
Mean hours range: 10,000 to 15,000
Flying training background: 71% Civil / 29% Military
Function: 84% Captains / 16% First Officers

Sub-group 2: Pilots aged 18 to 35
Mean hours range: 1,500 to 3,000
Flying training background: 97% Civil / 3% Military
Function: 15% Captains / 85% First Officers

Comparison/Subject Question. Percentage of pilots….	**Pilots aged 46 to 65 (n=349)**	**Pilots aged 18 to 35 (n=273)**	**% Difference**	**Is the difference statistically significant at a 95% level?**
Q2.2 … who have experienced failure of a flight guidance system or autopilot (in flight).	85%	64%	21%	Yes
Q2.5 … who have had an in-flight aircraft system or equipment failure that required them to fly the aircraft manually.	85%	58%	27%	Yes
Q2.6 … who have had an external factor that required them to fly the aircraft manually.	92%	70%	22%	Yes
Q2.7 … who feel very comfortable about conducting a flight of one hour duration with the Autoflight and/or Autothrust system inoperative.	40%	30%	10%	Yes

Q2.15 … who agreed their manual flying skills have become degraded since you started flying automated aircraft.	50%	40%	10%	Yes
Q2.21 … who strongly agree that manually flying an aircraft without FD guidance (i.e. FD switched off) would be more beneficial than hand flying but following a FD.	36%	46%	10%	Yes
Q3.10 Main reason(s) pilots may be reluctant to practice manual flying Statement# 6 (risk of FDM trigger pt.)	11%	22%	11%	Yes
Q3.11 … who thought a pilot who (after basic training) started their career on automated aircraft but practiced manual flight often would have better manual flying skills, when compared to a pilot who started their career flying a conventional aircraft before moving onto an automated aircraft, but does not practice manual flight.	48%	68%	20%	Yes
Q3.12 ii … who feel that their manual flying skills have improved since you started flying automated aircraft.	2%	15%	14%	Yes
Q 3.15 … who feel a less restrictive automation airline policy would be the most effective way for pilots to maintain or improve manual flying skills.	47%	63%	16%	Yes
Q4.1 … who agree and strongly agree (as PNF) the workload in the flight deck would be increased to an unacceptable level for normal operations if the "Pilot Flying/Handling Pilot" were to fly a descent and approach manually without the use of AP or FD (assuming good weather and low traffic levels).	28%	11%	17%	Yes
Q4.7 … who have ever been dissuaded from flying manually because they were mindful that that may trigger a FDM / FOQA event.	23%	38%	15%	Yes
Q4.8 … that have ever been dissuaded from flying manually because their colleague on the flight deck felt uncomfortable.	30%	63%	33%	Yes
Q4.11 … who felt very comfortable flying to a destination that they have previously visited and Air Traffic Control offers them a visual approach.	68%	45%	23%	Yes

Q5.1 … who strongly agree angle of attack information (alpha) should be displayed directly to the pilots on all public transport aircraft types.	42%	26%	16%	Yes
Q5.3 … who feel it is easier to notice a large airspeed deviation from an EFIS "speed tape" type display, when compared to a traditional round dial "analogue" airspeed indicator.	46%	72%	26%	Yes
Q5.9 …who perceive their fellow pilot's monitoring skills are very good or quite good.	67%	77%	10%	Yes

A.2 Comparisons by type of operation

Sub-group: Long-haul pilots
Mean age range: 46 to 55
Mean flying hours range: 10,000 to 15,000
Flying training background: 80% Civil / 20% Military
Function: 54% Captains / 46% First Officers

Sub-group: Short-haul pilots
Mean age range: 36 to 45
Mean flying hours range: 5,000 to 10,000
Flying training background: 92% Civil / 8% Military
Function: 49% Captains / 51% First Officers

Comparison/Subject Question. Percentage of pilots…	**Long haul (n=237)**	**Short haul (n=318)**	% Difference	Is the difference statistically significant at a 95% level?
Q2.6 … who have had an *external factor* that required them to fly the aircraft manually.	78%	85%	8%	Yes
Q2.7 … who feel *very comfortable* about conducting a flight of one hour duration with the Autoflight and/or Autothrust system inoperative.	29%	36%	7%	No
Q2.12 … who feel very comfortable flying "raw data"? (Flight without Flight Director, Autopilot/Auto Thrust).	32%	22%	10%	Yes
Q2.15 … who *agreed* or *strongly agreed* their manual flying skills have become degraded since they started flying automated aircraft.	81%	62%	19%	Yes

Q2.16 … who perceive their *colleagues'* manual flying skills to be currently *quite good* or *very good.*	28%	41%	13%	Yes
Q2.17 … who *agree* and *strongly agree* that their operator's automation policy is having a negative effect on maintaining manual flying skills.	49%	38%	11%	Yes
Q2.19 … who perceive their manual flying skills to be currently *quite good* or *very good.*	52%	61%	9%	Yes
Q3.1 … who *strongly agree* they would like more time available in the simulator to practice manual flying.	40%	26%	14%	Yes
Q3.3 … who have ever practiced manual flying in the real aircraft prior to a simulator check.	67%	78%	11%	Yes
Q3.4 … who *strongly agree* there is not enough time spent in the flight simulator practicing manual flight.	30%	19%	11%	Yes
Q3.5 … who *strongly agree* modern simulator recurrent training/checking is too much of a scripted "box ticking" exercise.	33%	25%	8%	Yes
Q3.8 … who *never* or *rarely* (apart from take-off/landing) fly manually.	61%	34%	27%	Yes
Q3.8 ii … who *quite often* or *very often* (apart from take-off and landing) fly manually.	17%	37%	20%	Yes
Q3.10 Main reason(s) pilots may be reluctant to practice manual flying Statement# 3 (easier to let AP work) Statement# 4 (more capacity/SA) Statement# 6 (risk of FDM trigger pt.)	12% 17% 14%	21% 9% 20%	9% 8% 6%	Yes Yes No
Q3.11 … who thought a pilot who (after basic training) started their career on automated aircraft but practiced manual flight often would have better manual flying skills, when compared to a pilot who started their career flying a conventional aircraft before moving onto an automated aircraft, but does not practice manual flight.	49%	64%	15%	Yes
Q3.12 … who feel that their manual flying skills have *deteriorated* since they started flying automated aircraft.	80%	63%	17%	Yes
Q3.12 ii … who feel that their manual flying skills have *improved* since you started flying automated aircraft.	1%	14%	13%	Yes, the Chi-square statistic is 31.0221 $p < 0.05$

Q 3.15 … who feel *more simulator training* would be the most effective way for pilots to maintain or improve manual flying skills.	39%	23%	16%	Yes
Q 3.15ii … who feel *a less restrictive airline automation policy* would be the most effective way for pilots to maintain or improve manual flying skills.	47%	63%	16%	Yes
Q4.1 … who *agree* or *strongly agree* (as PNF) the workload in the flight deck would be increased to an unacceptable level for normal operations if the "Pilot Flying/Handling Pilot" were to fly a descent and approach manually without the use of AP or FD (assuming good weather and low traffic levels).	27%	17%	10%	Yes
Q4.1 ii … who *disagree* or *strongly disagree* (as PNF) the workload in the flight deck would be increased to an unacceptable level for normal operations if the "Pilot Flying/ Handling Pilot" were to fly a descent and approach manually without the use of AP or FD (assuming good weather and low traffic levels).	61%	73%	12%	Yes
Q4.6 … *agree* or *strongly agree* that they think it is safer to use full automation at all times.	29%	18%	11%	Yes
Q4.6 ii … who *disagree* or *strongly disagree* that they think it is safer to use full automation at all times.	52%	66%	14%	Yes
Q 4.8 …who have ever been dissuaded from flying manually because their colleague on the flight deck felt uncomfortable.	39%	48%	9%	Yes
Q4.10 … *agree* or *strongly agree* that they think some pilots are just "lazy / too complacent" with regards to practicing manual flying.	54%	68%	14%	Yes
Q4.10 ii … who *disagree* or *strongly disagree* that they think some pilots are just "lazy / too complacent" with regards to practicing manual flying.	27%	15%	12%	Yes
Q5.2 … who *strongly agree* there should be more audio and visual warnings from aircraft designers to alert of low airspeed situations.	21%	10%	11%	Yes

Q5.3 … who feel it is easier to notice a large airspeed deviation from an EFIS "speed tape" type display, when compared to a traditional round dial "analogue" airspeed indicator.	54%	65%	11%	Yes
Q5.6 … who feel that autothrottle/ autothrust has changed the way they monitor their indicated airspeed and requires *less monitoring*.	46%	34%	12%	Yes

A.3 Comparisons of initial flying training background: Civilian / Military

Sub-group: Civilian (including integrated, modular and MPL)
Mean age range: 36 to 45
Mean hours range: 5,000 to 10,000
Function: 50% Captains / 50% First Officers

Sub-group: Military (including fixed wing and rotary wing)
Mean age range: 46 to 55
Mean hours range: 10,000 to 15,000
Function: 66% Captains / 34% First Officers

Comparison/Subject Question. Percentage of pilots….	**Civil (n=741)**	**Military (n=142)**	**% Difference**	**Is the difference statistically significant at a 95% level?**
Q2.5 … who have had an *in-flight aircraft system or equipment failure* that required them to fly the aircraft manually.	71%	80%	9%	Yes
Q3.10 Main reason(s) pilots may be reluctant to practice manual flying Statement# 3 (easier to let AP work) Statement# 10 (workload/airspace).	19% 7%	8% 14%	11% 7%	Yes Yes
Q3.11 … who thought a pilot who (after basic training) started their career on automated aircraft but practiced manual flight often would have better manual flying skills, when compared to a pilot who started their career flying a conventional aircraft before moving onto an automated aircraft, but does not practice manual flight.	55%	42%	13%	Yes

Q 3.15 … who feel more simulator training would be the most effective way for pilots to maintain or improve manual flying skills	29%	39%	10%	Yes
Q 3.15 ii … who feel a less restrictive automation airline policy would be the most effective way for pilots to maintain or improve manual flying skills	57%	47%	10%	Yes
Q4.1 … who *strongly agree* (as PNF) the workload in the flight deck would be increased to an unacceptable level for normal operations if the "Pilot Flying/Handling Pilot" were to fly a descent and approach manually without the use of AP or FD (assuming good weather and low traffic levels).	5%	13%	8%	Yes
Q4.1 ii … who *disagree* and *strongly disagree* (as PNF) the workload in the flight deck would be increased to an unacceptable level for normal operations if the "Pilot Flying/Handling Pilot" were to fly a descent and approach manually without the use of AP or FD (assuming good weather and low traffic levels).	68%	56%	12%	Yes
Q 4.8 … who have ever been dissuaded from flying manually because their colleague on the flight deck felt uncomfortable.	46%	34%	12%	Yes
Q 5.1 … who *strongly agree* angle of attack information (alpha) should be displayed directly to the pilots on all public transport aircraft types.	30%	49%	19%	Yes

A.4 Comparisons of Captains and First Officers

Sub-group: Captains (including Training Captains / Examiners)
Mean age range: 46 to 55
Mean hours range: 10,000 to 15,000
Flying training background: 80% Civil / 20% Military

Sub-group: First Officers (including Second Officers)
Mean age range: 26 to 35
Mean hours range: 3,000 to 5,000
Flying training background: 88% Civil / 12% Military

Comparison/Subject Question. Percentage of pilots….	**Captains** **(n=469)**	**First Officers (n=414)**	**% Difference**	**Is the difference statistically significant at a 95% level?**
Q2.2 … who have experienced failure of a flight guidance system or autopilot (in flight).	82%	65%	17%	Yes
Q2.5 … who have had an *in-flight aircraft system or equipment failure* that required them to fly the aircraft manually.	81%	63%	18%	Yes
Q2.6 … who have had an *external factor* that required them to fly the aircraft manually.	91%	73%	18%	Yes
Q2.7 … who feel *very comfortable* about conducting a flight of one hour duration with the Autoflight and/or Autothrust system inoperative.	40%	26%	14%	Yes
Q2.12 … who feel *very comfortable* flying "raw data"? (Flight without Flight Director, Autopilot/Auto Thrust).	30%	22%	8%	Yes
Q2.15 … who *strongly agree* their manual flying skills have become degraded since you started flying automated aircraft	23%	30%	7%	Yes
Q2.16 … who perceive their *colleagues'* manual flying skills to be currently *quite good* or *very good.*	30%	42%	12%	Yes
Q2.16 ii … who perceive their *colleagues'* manual flying skills to be currently *poor* or *could be better.*	30%	23%	7%	Yes
Q2.18 … who practice their manual flying skills *very often.*	30%	19%	11%	Yes
Q2.19 … who perceive their manual flying skills to be currently *quite good/very good.*	63%	50%	7%	Yes
Q2.19 ii … who perceive their manual flying skills to be currently *average.*	29%	39%	10%	Yes
Q3.10 Main reason(s) pilots may be reluctant to practice manual flying. Statement# 6 (risk of FDM trigger point).	14%	23%	9%	Yes

Q3.11 … who thought a pilot who (after basic training) started their career on automated aircraft but practiced manual flight often would have better manual flying skills, when compared to a pilot who started their career flying a conventional aircraft before moving onto an automated aircraft, but does not practice manual flight.	50%	56%	6%	No
Q4.1 … who *strongly agree* and *agree* (as PNF) the workload in the flight deck would be increased to an unacceptable level for normal operations if the "Pilot Flying/Handling Pilot" were to fly a descent and approach manually without the use of AP or FD (assuming good weather and low traffic levels).	27%	15%	12%	Yes
Q4.7 … who have ever been dissuaded from flying manually because they were mindful that that may trigger a FDM / FOQA event.	26%	38%	12%	Yes
Q 4.8 … who have ever been dissuaded from flying manually because their colleague on the flight deck felt uncomfortable.	29%	60%	31%	Yes
Q 4.11 … who felt *very comfortable* flying to a destination that they have previously visited and Air Traffic Control offers them a visual approach; the weather is nice and traffic levels are low.	66%	45%	21%	Yes
Q 5.1 … who *strongly agree* angle of attack information (alpha) should be displayed directly to the pilots on all public transport aircraft types.	37%	28%	11%	Yes
Q 5.3 … who feel it is easier to notice a large airspeed deviation from an EFIS "speed tape" type display, when compared to a traditional round dial "analogue" airspeed indicator.	51%	64%	13%	Yes

Q 5.6 … who feel that autothrottle/autothrust has changed the way they monitor their indicated airspeed and requires *less monitoring*.	36%	45%	9%	Yes
Q 5.9 …who perceive their fellow pilot's monitoring skills are *very good.*	13%	23%	10%	Yes

A.5 Comparisons by number of flying hours

Sub-group: Pilots with 15,000+ hours
Mean age range: 56 to 65
Flying training background: 73% Civil / 27% Military
Function: 91% Captains / 9% First Officers

Sub-group: Pilots with 200 to 3,000 hours
Mean age range: 26 to 35
Flying training background: 88% Civil / 12% Military
Function: 7% Captains / 93% First Officers

Comparison/Subject Question. Percentage of pilots….	**High hours (n=194)**	**Low hours (n=147)**	**% Difference**	**Is the difference statistically significant at a 95% level?**
Q2.2 … who have experienced failure of a flight guidance system or autopilot (in flight).	85%	58%	27%	Yes
Q2.3 … who have received from their *operator* any guidance regarding maintaining manual flying skills.	59%	49%	10%	No
Q2.5 … who have had an *in-flight aircraft system or equipment failure* that required them to fly the aircraft manually.	84%	49%	35%	Yes
Q2.6 … who have had an *external factor* that required them to fly the aircraft manually.	93%	63%	30%	Yes
Q2.7 … who feel *very comfortable* about conducting a flight of one hour duration with the Autoflight and/or Autothrust system inoperative.	45%	27%	18%	Yes

Q2.10 … who *strongly agreed* manual flying skills will decrease over time if they do not practice them.	65%	74%	9%	No
Q2.11 … who *strongly agree* they like to hand fly part of every flight to keep their skills up.	55%	42%	13%	Yes
Q2.12 … who feel *very comfortable* flying "raw data"? (Flight without Flight Director, Autopilot/Autothrust).	34%	27%	7%	No
Q2.15 … who *agreed* their manual flying skills have become degraded since you started flying automated aircraft.	51%	37%	14%	Yes
Q2.18 … who practice their manual flying skills *very often.*	38%	20%	18%	Yes
Q2.19 … who perceive their manual flying skills to be currently *very good.*	14%	5%	9%	Yes
Q3.3 … who have ever practiced manual flying in the real aircraft prior to a simulator check.	80%	67%	13%	Yes
Q3.7 … who *strongly agree* more emphasis should be placed on assessing a pilot's manual flying skills in a flight simulator.	29%	12%	17%	Yes
Q3.8 … who *quite often* (apart from take-off and landing) fly manually.	26%	17%	9%	Yes
Q3.10 Main reason(s) pilots may be reluctant to practice manual flying # 3 (easier to let AP work) # 4 (more capacity/SA) # 6 (risk of FDM trigger pt.)	 22% 16% 8%	 16% 11% 22%	 6% 5% 14%	 No No Yes
Q3.11 … who thought a pilot who (after basic training) started their career on automated aircraft but practiced manual flight often would have better manual flying skills, when compared to a pilot who started their career flying a conventional aircraft before moving onto an automated aircraft, but does not practice manual flight.	43%	76%	33%	Yes

Q3.12 … who feel that their manual flying skills have *deteriorated* since they started flying automated aircraft.	74%	58%	16%	Yes
Q3.12 ii … who feel that their manual flying skills have *improved* since you started flying automated aircraft.	1%	20%	19%	Yes, Chi-square statistic is 36.9274. $p < 0.05$
Q3.15 … who thought *more simulator training* would be the most effective way for pilots to maintain or improve manual flying skills.	38%	24%	14%	Yes
Q3.15 ii … who feel *a less restrictive automation airline policy* would be the most effective way for pilots to maintain or improve manual flying skills.	47%	57%	10%	No
Q4.1 … who *agree* and *strongly agree* (as PNF) the workload in the flight deck would be increased to an unacceptable level for normal operations if the "Pilot Flying/Handling Pilot" were to fly a descent and approach manually without the use of AP or FD (assuming good weather and low traffic levels).	30%	13%	17%	Yes
Q4.7 … who have ever been dissuaded from flying manually because they were mindful that that may trigger a FDM event.	18%	39%	21%	Yes
Q4.8 …who have ever been dissuaded from flying manually because their colleague on the flight deck felt uncomfortable.	24%	62%	38%	Yes
Q4.11 … who felt *very comfortable* flying to a destination that they have previously visited and Air Traffic Control offers them a visual approach.	72%	41%	31%	Yes
Q4.11 ii … who felt *somewhat uncomfortable* flying to a destination that they have previously visited and Air Traffic Control offers them a visual approach.	4%	12%	8%	Yes

Q5.1 …who *strongly agree* angle of attack information (alpha) should be displayed directly to the pilots on all public transport aircraft types.	44%	20%	24%	Yes
Q5.2 … who *strongly agree* there should be more audio and visual warnings from aircraft designers to alert of low airspeed situations.	18%	9%	9%	Yes
Q5.3 … who feel it is easier to notice a large airspeed deviation from an EFIS “speed tape” type display, when compared to a traditional round dial “analogue” airspeed indicator.	47%	72%	25%	Yes
Q5.9 …who perceive their fellow pilot's monitoring skills are *very good* or *quite good.*	61%	78%	17%	Yes

A.6 Comparison: Corporate / Business aviation pilots

Sub-group: Corporate/Business aviation pilots
Mean age range: 46 to 55
Mean hours range: 5,000 to 10,000
Flying training background: 85% Civil / 15% Military
Function: 80% Captains / 20% First Officers

Sub-group: Non corporate pilots
Mean age range: 36 to 45
Mean hours range: 5,000 to 10,000
Flying training background: 84% Civil / 16% Military
Function: 50% Captains / 50% First Officers

Comparison/Subject Question. Percentage of pilots…	Corporate (n=71)	Non Corporate (n=812)	% Difference	Is the difference statistically significant at a 95% level?
Q2.2 … who have experienced failure of a flight guidance system or autopilot (in flight).	92%	73%	19%	Yes
Q2.5 … who have had an *in-flight aircraft system or equipment failure* that required them to fly the aircraft manually.	93%	71%	22%	Yes

Q2.6 … who have had an *external factor* that required them to fly the aircraft manually.	94%	82%	12%	Yes
Q2.7 … who feel *very comfortable* about conducting a flight of one hour duration with the Autoflight and/or Autothrust system inoperative.	54%	31%	23%	Yes
Q2.12 … who feel *very comfortable* flying "raw data"? (Flight without Flight Director, Autopilot/Autothrust).	42%	25%	17%	Yes
Q2.15 … who *strongly agreed* their manual flying skills have become degraded since you started flying automated aircraft.	8%	28%	20%	Yes
Q2.18 … who practice their manual flying skills *very often.*	37%	24%	13%	Yes
Q2.19 … who perceive their manual flying skills to be currently *quite good* or *very good.*	81%	54%	27%	Yes
Q3.2 … whose operators' recurrent training schedule allows sufficient time to practice manual flying in the flight simulator.	31%	17%	14%	Yes
Q3.8 … who *quite often* and *very often* (apart from take-off and landing) fly manually.	48%	25%	23%	Yes
Q3.11 … who thought a pilot who (after basic training) started their career on automated aircraft but practiced manual flight often would have better manual flying skills, when compared to a pilot who started their career flying a conventional aircraft before moving onto an automated aircraft, but does not practice manual flight.	42%	54%	12%	No* However at 90% level, yes. The Chi-square statistic is 3.5803. The P value is 0.05847
Q3.12 … who feel that their manual flying skills have *deteriorated* since they started flying automated aircraft.	49%	71%	22%	Yes
Q3.13 … who do extra flying outside of work.	45%	75%	30%	Yes

Q4.8 … who have ever been dissuaded from flying manually because their colleague on the flight deck felt uncomfortable.	23%	45%	22%	Yes
Q4.11 … who felt *very comfortable* flying to a previously visited destination and Air Traffic Control offers them a visual approach	80%	54%	26%	Yes
Q5.1 … who *agree* and *strongly agree* angle of attack information (alpha) should be displayed directly to the pilots on all public transport aircraft types	88%	62%	26%	Yes
Q5.5 … who *strongly agree* with some aircraft having full flight envelope protection with fly by wire/auto-trim, there is benefit in practicing manual flight in these types, given that failures in equipment are rare	46%	33%	13%	Yes
Q5.8 … who received from their operator any specific guidance with regards to maintaining or improving monitoring skills.	31%	53%	22%	Yes

A.7 Comparisons by type of aircraft: Boeing 737 / Airbus A320

Sub-group: Boeing 737 pilots
Mean age range: 36 to 45
Mean flying hours range: 3,000 to 5,000
Flying training background: 84% Civil / 16% Military
Function: 36% Captains / 64% First Officers

Sub-group: Airbus A320 series pilots
Mean age range: 36 to 45
Mean flying hours range: 5,000 to 10,000
Flying training background: 93% Civil / 7% Military
Function: 55% Captains / 45% First Officers

Comparison/Subject Question. Percentage of pilots…	**Boeing 737 (n=116)**	**Airbus A320 series (n=160)**	**% Difference**	**Is the difference statistically significant at a 95% level?**
Q2.2 … who have experienced failure of a flight guidance system or autopilot (in flight).	78%	64%	14%	Yes
Q2.3 … who have received from their *operator* any guidance regarding maintaining manual flying skills.	59%	44%	15%	Yes
Q2.5 … who have had an *in-flight aircraft system or equipment failure* that required them to fly the aircraft manually.	68%	61%	7%	No
Q2.7 … who feel *very comfortable* about conducting a flight of one hour duration with the Autoflight and/or Autothrust system inoperative.	39%	26%	13%	Yes
Q2.8 … who see colleagues practice manual flying skills *often* and *very often.*	30%	15%	15%	Yes
Q2.8 ii … who see colleagues practice manual flying skills *not at all*.	0%	13%	13%	Yes, the Chi-square statistic is 15.6328. $p < 0.05$
Q2.12 … who feel *very comfortable* flying "raw data"? (Flight without Flight Director, Autopilot/Autothrust).	40%	26%	14%	Yes
Q2.15 … who *agreed* and *strongly agreed* their manual flying skills have become degraded since you started flying automated aircraft.	54%	65%	11%	No
Q2.16 … who perceive their *colleagues'* manual flying skills to be currently *quite good* or *very good.*	53%	35%	18%	Yes
Q2.16 ii … who perceive their *colleagues'* manual flying skills to be currently *poor* or *could be better.*	19%	35%	16%	Yes
Q2.18 … who practice their manual flying skills *very often.*	28%	18%	10%	Yes
Q2.18 ii … who practice their manual flying skills *very occasionally.*	7%	26%	19%	Yes

Q3.1 … who *agree* and *strongly agree* they would like more time available in the simulator to practice manual flying.	65%	79%	14%	Yes
Q3.2 … whose operators' recurrent training schedule *does not allow* sufficient time to practice manual flying in the flight simulator.	45%	33%	12%	Yes
Q3.4 … who *agree* there is not enough time spent in the flight simulator practicing manual flight.	29%	49%	20%	Yes
Q3.6 … who have recently received any simulator training specifically for upset recovery (in the last 36 months).	91%	78%	13%	Yes
Q3.8 … who *never* or *rarely* fly manually other than take-off or landing.	20%	51%	31%	Yes
Q3.8ii … who *quite often* or *very often* fly manually other than take-off or landing.	45%	24%	21%	Yes
Q3.10 Main reason(s) pilots may be reluctant to practice manual flying #3 (easier to let AP work) # 4 (more capacity/SA) # 6 (risk of FDM trigger pt.)	 22% 10% 19%	 16% 16% 28%	 6% 6% 9%	 No No No
Q3.12 … who feel that their manual flying skills have *deteriorated* since they started flying automated aircraft.	52%	67%	15%	Yes
Q3.12 ii … who feel that their manual flying skills have *improved* since you started flying automated aircraft.	22%	8%	14%	Yes
Q3.15 … who *more simulator training* would be the most effective way for pilots to maintain or improve manual flying skills.	18%	31%	13%	Yes
Q4.8 …who have ever been dissuaded from flying manually because their colleague on the flight deck felt uncomfortable.	57%	48%	9%	No
Q5.4 … who *strongly agree* if that an aircraft is fitted with "trend vectors" on the primary flight display instruments, that this makes manual flight easier.	29%	49%	20%	Yes

Q5.5 … who *strongly agree* with some aircraft having full flight envelope protection with fly by wire/auto-trim, there is benefit in practicing manual flight in these types, given that failures in equipment are rare.	26%	41%	15%	Yes
Q5.6 … who feel that Autothrottle/Autothrust has changed the way they monitor their indicated airspeed and requires *less monitoring*.	27%	57%	30%	Yes

A.8 Comparisons by type of aircraft: Boeing 777 / Airbus A330

Sub-group: Boeing 777 pilots
Mean age range: 36 to 45
Mean flying hours range: 5,000 to 10,000
Flying training background: 83% Civil / 17% Military
Function: 39% Captains / 61% First (and Second) Officers

Sub-group: Airbus A330 pilots
Mean age range: 36 to 45
Mean flying hours range: 10,000 to 15,000
Flying training background: 71% Civil / 29% Military
Function: 54% Captains / 46% First (and Second) Officers

Comparison/Subject Question. Percentage of pilots…	**Boeing 777 (n=122)**	**Airbus A330 (n=127)**	**% difference**	**Is the difference statistically significant at a 95% level?**
Q2.7 … who feel *very comfortable* about conducting a flight of one hour duration with the Autoflight and/or Autothrust system inoperative.	19%	28%	9%	No
Q2.13 … who have ever noticed a colleague practice manual flying prior to a proficiency check in a flight simulator.	57%	78%	21%	Yes
Q2.21 … who *strongly agree* that manually flying an aircraft without FD guidance (i.e. FD switched off) would be more beneficial than hand flying but following a FD.	39%	46%	7%	No

Q3.3 …who ever practiced manual flying in the real aircraft prior to a simulator check .	57%	72%	15%	Yes
Q3.4… who *agree* there is not enough time spent in the flight simulator practicing manual flight.	42%	57%	15%	Yes
Q3.6 … who have recently received any simulator training specifically for upset recovery (in the last 36 months).	92%	83%	9%	Yes
Q3.10 Main reason(s) pilots may be reluctant to practice manual flying #1 (tiredness/fatigue) # 3 (easier to let AP work) # 4 (more capacity/SA) # 6 (risk of FDM trigger pt.) # 8 (safer to use AP)	15% 7% 23% 23% 7%	20% 12% 10% 19% 12%	5% 5% 13% 4% 5%	No No Yes No No
Q4.4 … who *strongly agree* that airline/commercial schedules are generally just too busy that pilots may be too tired to practice manual flying.	22%	35%	13%	Yes
Q4.7 … who have ever been dissuaded from flying manually because they were mindful that that may trigger a FDM / FOQA event.	44%	31%	13%	Yes
Q 4.8 … who have ever been dissuaded from flying manually because their colleague on the flight deck felt uncomfortable.	48%	39%	9%	Yes
Q4.11 … who felt *very comfortable* flying to a destination that they have previously visited and ATC offers them a visual approach.	28%	42%	14%	Yes
Q5.1 … who *strongly agree* angle of attack information (alpha) should be displayed directly to the pilots on all public transport aircraft types.	30%	39%	9%	No
Q5.5 …who *agree* or *strongly agree* with some aircraft having full flight envelope protection with fly by wire/auto-trim, there is benefit in practicing manual flight in these types, given that failures in equipment are rare.	68%	82%	14%	Yes

A.9 Comparison: By region

Only regions with a sample population of >50 were used. The results may be seen in histogram from in chapter 4, Figure 4.13.

Sub-group: Pilots based in the United Kingdom/Ireland
Mean age range: 36 to 45
Mean flying hours range: 5,000 to 10,000
Flying training background: 90% Civil / 10% Military
Function: 56% Captains / 44% First Officers
n=97

Sub-group: Pilots based in Western Europe
Mean age range: 36 to 45
Mean flying hours range: 5,000 to 10,000
Flying training background: 84% Civil / 16% Military
Function: 53% Captains / 47% First Officers
n=280

Sub-group: Pilots based in the Middle East
Mean age range: 36 to 45
Mean flying hours range: 5,000 to 10,000
Flying training background: 89% Civil / 11% Military
Function: 61% Captains / 39% First Officers
n=72

Sub-group: Pilots based in Asia
Mean age range: 36 to 45
Mean flying hours range: 5,000 to 10,000
Flying training background: 78% Civil / 22% Military
Function: 42% Captains / 50% First Officers / Second Officers 8%
n=202

Sub-group: Pilots based in North America
Mean age range: 46 to 55
Mean flying hours range: 10,000 to 15,000
Flying training background: 71% Civil / 29% Military
Function: 67% Captains / 33% First Officers
n=105

Sub-group: Pilots based in South America
Mean age range: 26 to 35
Mean flying hours range: 5,000 to 10,000
Flying training background: 98% Civil / 2% Military
Function: 59% Captains / 41% First Officers
n=54

A.10 MPL pilot group

Sub-group: MPL pilots
Mean age range: 26 to 35
Mean flying hours range: 3,000 to 5,000
Function: 21% Captains / 79% First Officers

Subject Question. Percentage of pilots…	**MPL** **n=19**
Q2.2 … who have experienced failure of a flight guidance system or autopilot (in flight).	53%
Q2.6 … who have had an *external factor* that required them to fly the aircraft manually.	68%
Q2.9 … who *agree* or *strongly agreed* about a possible loss of manual flying skills with too much automation.	84%
Q2.10 … who *agree* or *strongly agreed* manual flying skills will decrease over time if they do not practice them.	100%
Q2.15 … who *agree* or *strongly agree* their manual flying skills have become degraded since you started flying automated aircraft.	84%
Q3.2 … whose operators' recurrent training schedule allows sufficient time to practice manual flying in the flight simulator.	5%
Q3.6 … who have recently received any simulator training specifically for upset recovery (in the last 36 months).	95%
Q3.12 … who feel that their manual flying skills have *deteriorated* since they started flying automated aircraft	84%
Q4.2 … who have ever found the aircraft to be in an automated mode which was not expected and then resolved the situation by reverting to manual flight.	89%
Q 4.3 … who have ever noticed the performance of a colleague on the flight deck be affected by tiredness or fatigue.	100%
Q4.7 … who have ever been dissuaded from flying manually because they were mindful that that may trigger a FDM / FOQA event.	37%
Q4.8 …who have ever been dissuaded from flying manually because their colleague on the flight deck felt uncomfortable.	37%
Q5.3 … who feel it is easier to notice a large airspeed deviation from an EFIS "speed tape" type display, when compared to a traditional round dial "analogue" airspeed indicator	79%

Appendix B - Manual Flying Survey

Manual flying survey - Introduction

As part of an MSc course in “Human Factors in Safety Assessment in Aeronautics” at Cranfield University, I am conducting a research Thesis related to the manual flying skills of pilots of automated aircraft.

So if you are the holder of an Airline Transport Pilot Licence (ATPL) or Commercial Pilot Licence (CPL) and have a type rating on a multi-engine jet or turboprop aircraft, then your participation in this study would be greatly appreciated.

Why are you being asked to take part?

Loss of Control in flight (LOC-I) is now the main cause of fatal aircraft accidents. Several recent accidents may have had different outcomes if the crews involved had demonstrated a higher level of monitoring and manual flying skills. Incorrect or poor manual flying technique can also lead to other events such as unstable approaches, hard landings, runway excursions and flap over speeds.

As part of this research I am looking to ascertain the current views of professional pilots with regards to the importance of manual flying skills and the main factors that may lead to retention or loss of those skills.

Whilst there have been previous academic studies looking at automation related issues and measuring manual flying performance in a flight simulator, these have generally been confined to relatively small groups of specific pilots from one particular organisation or a single aircraft type. The main aim of this survey is to get the input of a larger group of pilots from throughout the industry on how they perceive issues (such as training, monitoring, workload and aircraft design) in line operations under real world conditions. The data collected will be used to identify and highlight any trends and issues that are becoming evident in the industry.

How long will it take?

The survey is divided into 5 sections and should only take around 10 to 15 minutes to complete. Please use the   button at the bottom right side of each page to proceed when you have read all the information.

Further information

For the purpose of these questions, please consider the words “manual flying” to mean flight without autopilot and/or autothrottle/autothrust and flight director systems. “Automated aircraft” will have at least one autopilot, flight director and flight management system.

Please answer all the applicable questions based on your experience. There are no right or wrong answers.

Participation is on a voluntary basis and all participants will remain anonymous. It will not be possible to identify any specific individual from the data provided as a result of this research.

You can withdraw from the study at any time, without giving a reason and without repercussions. Should you wish to withdraw your information at any point after you have completed the survey please e-mail the date/time you undertook the survey by 31st July 2014 and the record will be removed from the collected data.

Please understand that any information you provide will be treated confidentially and stored securely.

Many thanks for your time, it is highly appreciated!

Peter Wilson
Cranfield University MSc Student & Airline Training Captain.
p.s.wilson@cranfield.ac.uk

By ticking the check box below, you confirm that you have read this page completely and you fully understand the information provided on it and therefore give consent to take part in this research. You understand that the data collected will only be used for research purposes as part of the Human Factors & Safety Assessment in Aeronautics MSc thesis project conducted by Peter Wilson who is a student at Cranfield University.

❑ I accept I have read and understood the information provided above.

Section 1: Your flying background / Experience

Please indicate your initial flying training background:
- ❍ CIVIL - Full time course / Integrated / CAP 509
- ❍ CIVIL - Modular / Self Improver
- ❍ CIVIL - MPL (Airline specific Multi Pilot Licence, introduced from 2006 for cadet pilots)
- ❍ MILITARY - Fixed wing
- ❍ MILITARY - Rotary wing

Please indicate your flying experience (in hours):
- ❍ 200 to 1,500
- ❍ 1,500 to 3,000
- ❍ 3,000 to 5,000
- ❍ 5,000 to 10,000
- ❍ 10,001 to 15,000
- ❍ 15,000 +

Please indicate your age range:
- ❍ 18 to 25
- ❍ 26 to 35
- ❍ 36 to 45
- ❍ 46 to 55
- ❍ 56 to 65
- ❍ I would rather not say

Please indicate your current aircraft type (or most recent):

- Airbus A300 / 310
- Airbus A318 / 319 / 320 / 321
- Airbus A330
- Airbus A340
- Airbus A380
- Boeing 717
- Boeing 737 - 300 to 900 / BBJ
- Boeing 747 - 400 / 747-8
- Boeing 757
- Boeing 767
- Boeing 777
- Boeing 787
- MD 80 series / DC-9
- MD11/10 (DC-10)
- MD90
- Embraer 135 / 140 / 145
- Embraer 170 / 175 / 190 / 195 / Lineage
- Embraer 120
- DHC 8 Q400
- DHC 8 100/200/300
- Bombardier Learjet series
- Bombardier Global Series
- Bombardier Challenger series
- Bombardier CRJ 100-900
- SAAB 340
- SAAB 2000
- Dornier 328TP/328J
- ATR 42/72 series 200/300/500/600
- BAe Jetstream 41
- BAe 146/AVRO RJ
- BAe ATP
- Fokker 50
- Fokker 70/100
- Gulfstream GIV/450/V/550/650
- Gulfstream G150/200/280
- Dassault Falcon 50/2000/900/7X
- Beechcraft Kingair series
- Hawker HS125/800
- Cessna Citation Series
- Lockheed Tri-Star
- Other type - not listed

Your current (or most recent) position:

- ❍ Captain
- ❍ Training Captain / Instructor / TRE / TRI / SFI / SFE / Check airman
- ❍ First Officer / Senior First Officer / Training First Officer
- ❍ Second Officer (Cruise relief pilot)

Region where you are primarily based:

- ❍ UK / Ireland
- ❍ Western Europe
- ❍ Eastern Europe
- ❍ Middle East
- ❍ Asia
- ❍ Africa
- ❍ North America (USA / CANADA)
- ❍ South America
- ❍ Australia / New Zealand

What type of operations do you currently fly? (May select more than one):

- ❑ Regional / Short haul
- ❑ Mid-haul
- ❑ Long haul
- ❑ Corporate / Business Aviation
- ❑ Cargo / Air Freight

Section 2: Manual Flight Requirements

Q 2.1 Do you agree that good manual flying skills are essential for any airline/commercial pilot?
- ❍ Strongly agree
- ❍ Agree
- ❍ Neutral
- ❍ Disagree
- ❍ Strongly disagree

Q 2.2 Have you ever been faced with failure of a flight guidance system or autopilot (in flight)?
- ❍ Yes
- ❍ No

Q 2.3 Have you received from your operator any specific guidance with regards to maintaining manual flying skills?
- ❍ Yes
- ❍ No

Q 2.4 Have you received from your regulator (e.g. CAA / FAA/ DGAC) any specific guidance with regards to maintaining manual flying skills?
- ❍ Yes
- ❍ No

Q 2.5 Have you ever been faced with an in-flight aircraft system or equipment failure that required you to fly the aircraft manually?
- ❍ Yes
- ❍ No

Q 2.5.1 If you answered "yes", please provide a very brief description of what system or equipment failed that required you to fly the aircraft manually (e.g. Autoflight, flying controls etc.)?

Q 2.6 Have you ever been faced with an external factor that required you to fly the aircraft manually (e.g. turbulence, wake vortex, upset recovery, TCAS RA etc.)?
- ❍ Yes
- ❍ No

Q 2.6.1 If you answered "yes", please provide a very brief description of the kind of event(s) that required you to fly the aircraft manually and on how many occasions they have occurred (approximately).

Q 2.7 How would you feel about conducting a flight of one hour duration with the Autoflight and/or Autothrust system inoperative (assuming it is fitted and allowed under your aircraft's MEL and that you will not be required to fly in RVSM airspace)?
- ❍ Very comfortable
- ❍ Somewhat comfortable
- ❍ Neutral
- ❍ Somewhat uncomfortable
- ❍ Very uncomfortable

Q 2.8 I see colleagues practice manual flying skills:
- ❍ Very often (on every flight where possible)
- ❍ Often (on more than 50% of flights)
- ❍ Sometimes (between 10-50% of flights)
- ❍ Very occasionally (between 0-10 % of flights)
- ❍ Not at all

Q 2.9 I am concerned about a possible loss of my manual flying skills with too much automation:
- ❍ Strongly agree
- ❍ Agree
- ❍ Neutral
- ❍ Disagree
- ❍ Strongly disagree

Q 2.10 Do you think your manual flying skills will decrease over time if you do not practice them?
- ❍ Strongly agree
- ❍ Agree
- ❍ Neutral
- ❍ Disagree
- ❍ Strongly disagree

- ❍ Q 2.11 I like to hand fly part of every flight to keep my skills up:
- ❍ Strongly agree
- ❍ Agree
- ❍ Neutral
- ❍ Disagree
- ❍ Strongly disagree

Q 2.12 How comfortable do you feel flying "raw data"? (Flight without Flight Director, Autopilot/Autothrust):
- ❍ Very comfortable
- ❍ Somewhat comfortable
- ❍ Neutral
- ❍ Somewhat uncomfortable
- ❍ Very uncomfortable

Q 2.13 Have you ever noticed a colleague practice manual flying prior to a proficiency check in a flight simulator?

- ❍ Yes
- ❍ No

Q 2.14 My operator's attitude to maintaining manual flying skills is:

- ❍ Make use of automation at all times
- ❍ Use an appropriate level of automation as required
- ❍ Neutral
- ❍ Encouraged whenever possible
- ❍ Not specified

Q 2.15 Do you think your manual flying skills have become degraded since you started flying automated aircraft?

- ❍ Strongly agree
- ❍ Agree
- ❍ Neutral
- ❍ Disagree
- ❍ Strongly disagree

Q 2.16 In general, how would you perceive your fellow pilots' manual flying skills are at the moment?

- ❍ Very good
- ❍ Quite good
- ❍ Average
- ❍ Could be better
- ❍ Poor

Q 2.17 I feel that my operator's automation policy is having a negative effect on maintaining manual flying skills:

- ❍ Strongly agree
- ❍ Agree
- ❍ Neutral
- ❍ Disagree
- ❍ Strongly disagree

Q 2.18 I practice my manual flying skills:

- ❍ Very often (on every flight where possible)
- ❍ Often (on more than 50% of flights where possible)
- ❍ Sometimes (between 10-50% of flights where possible)
- ❍ Very occasionally (between 0-10 % of flights where possible)
- ❍ Not at all

Q 2.19 How do you perceive your manual flying skills are at the moment?
- Very good
- Quite good
- Average
- Could be better
- Poor

Q 2.20 Do you think it is necessary to improve basic airmanship and manual flying skills of pilots?
- Strongly agree
- Agree
- Neutral
- Disagree
- Strongly disagree

Q 2.21 In order to maintain flying skills, do you think that manually flying an aircraft without Flight Director guidance (i.e. Flight Director switched off) would be more beneficial than hand flying but following a Flight Director?
- Strongly agree
- Agree
- Neutral
- Disagree
- Strongly disagree

Section 3: Training

Q 3.1 The amount of training: Would you like more time available in the simulator to practice manual flying?

- Strongly agree
- Agree
- Neutral
- Disagree
- Strongly disagree

Q 3.2 Does your operator's recurrent training schedule allow you sufficient time to practice manual flying in the flight simulator?

- Yes
- Sometimes
- No

Q 3.3 Have you ever practiced manual flying in the real aircraft prior to a simulator check?

- Yes
- No

Q 3.4 There is not enough time spent in the flight simulator practicing manual flight:

- Strongly agree
- Agree
- Neutral
- Disagree
- Strongly disagree

Q 3.5 Do you think modern simulator recurrent training/checking is too much of a scripted "box ticking" exercise?

- Strongly agree
- Agree
- Neutral
- Disagree
- Strongly disagree

Q 3.6 Upset recovery training/stall: Have you recently received any simulator training specifically for upset recovery (in the last 36 months)?

- Yes
- No

Q 3.7 Do you think more emphasis should be placed on assessing a pilot's manual flying skills in a flight simulator?

- Strongly agree
- Agree
- Neutral
- Disagree
- Strongly disagree

Q 3.8 Apart from take-off and landing, how much manual flying do you really do?
❍ Never
❍ Rarely
❍ Sometimes
❍ Quite often
❍ Very often

Q 3.9 With regard to (some) pilots being reluctant to practice their manual flying skills: Why do you think (some) pilots may be reluctant to practice manual flying?

	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree
1. They are feeling tired/fatigued from a busy schedule.	❍	❍	❍	❍	❍
2. They are not sure what their manual flying skills will look like.	❍	❍	❍	❍	❍
3. It is easier to let the automatics do the work.	❍	❍	❍	❍	❍
4. They will have more capacity for monitoring/situational awareness if using automatics.	❍	❍	❍	❍	❍
5. It is smoother for passengers to let the autopilot do the work.	❍	❍	❍	❍	❍
6. They don't want to risk triggering an FDM / FOQA event.	❍	❍	❍	❍	❍
7. They are lazy.	❍	❍	❍	❍	❍
8. They think it is safer to use automatics than manual flying.	❍	❍	❍	❍	❍
9. They don't want to overload the other pilot with extra monitoring.	❍	❍	❍	❍	❍
10. Workload is too high, airspace is too busy.	❍	❍	❍	❍	❍
11. Lack of opportunity.	❍	❍	❍	❍	❍
12. Nobody else does it.	❍	❍	❍	❍	❍

Q 3.10 Of the 12 statements above in Q3.9, please select from the drop down list (below) the number relating to which statement you think is the main reason pilots may be reluctant to practice manual flying:

- ❍ Statement # 1
- ❍ Statement # 2
- ❍ Statement # 3
- ❍ Statement # 4
- ❍ Statement # 5
- ❍ Statement # 6
- ❍ Statement # 7
- ❍ Statement # 8
- ❍ Statement # 9
- ❍ Statement # 10
- ❍ Statement # 11
- ❍ Statement # 12

Q 3.11 Regarding recency in manual flying tasks with regards to performance:
Who do you think would be most likely to have better manual flying skills?

- ❍ A pilot who (after basic training) started their career on automated aircraft but practiced manual flight often.
- ❍ A pilot who started their career flying a conventional aircraft before moving onto an automated aircraft, but does not practice manual flight.

Q 3.12 Do you feel that your manual flying skills have been affected since you started flying automated aircraft?

- ❍ Yes, they have improved
- ❍ No, they have not changed
- ❍ Yes, they have deteriorated

Q 3.13 Do you fly outside of work?

- ❑ Gliding
- ❑ Light aircraft (fixed wing or rotary)
- ❑ Aerobatics
- ❑ Flight instruction
- ❑ I do no extra flying outside of work

Q 3.14 How do you think your manual flying skills will be in the future if you do not practice them?

- ❍ They will decline
- ❍ They will stay the same
- ❍ They will improve

Q 3.15 What do you think would be the most effective way for pilots to maintain or improve manual flying skills?

- ❍ More simulator training
- ❍ Less restrictive automation airline policy
- ❍ More assessment / regulation
- ❍ Extra training in light aircraft / gliders

Section 4: Workload and performance

Obviously there are situations where it is not possible to practice manual flight, such as RVSM airspace and occasions such as very busy airspace and/or poor weather conditions when workload will likely be very high.

Q 4.1 If you are the “Pilot Monitoring/Non Handling Pilot”, do you feel the workload in the flight deck would be increased to an unacceptable level for normal operations if the “Pilot Flying/Handling Pilot” were to fly a descent and approach manually without the use of Autopilots or Flight Directors (assume good weather and low traffic levels)?

- Strongly agree
- Agree
- Neutral
- Disagree
- Strongly disagree

Q 4.2 Have you ever found the aircraft to be in an automated mode which you were not expecting and then resolved the situation by reverting to manual flight?

- Yes
- No

Q 4.3 Have you ever noticed the performance of a colleague on the flight deck be affected by tiredness or fatigue?

- Yes
- No

Q 4.4 Do you believe airline/commercial schedules are generally just too busy that pilots may be too tired to practice manual flying?

- Strongly agree
- Agree
- Neutral
- Disagree
- Strongly disagree

Q 4.5 Have you ever felt so tired or fatigued that you feel you could not fly the aircraft safely without automation?

- Strongly agree
- Agree
- Neutral
- Disagree
- Strongly disagree

Q 4.6 Do you think it is safer to use full automation at all times?

- Strongly agree
- Agree
- Neutral
- Disagree
- Strongly disagree

Q 4.7 Flight Data Monitoring (FDM): Have you ever been dissuaded from flying manually because you were mindful that you may trigger a FDM / FOQA event?

- ❍ Yes
- ❍ Not applicable / not fitted to my aircraft type
- ❍ No

Q 4.8 Have you ever been dissuaded from flying manually because your colleague on the flight deck felt uncomfortable?

- ❍ Yes
- ❍ No

Q 4.9 What methods do you use to maintain manual flying skill proficiency?

- ❑ Manually flying when the situation allows (the weather is nice and the workload is low)
- ❑ Flight simulators
- ❑ Flying outside of work
- ❑ Normal take offs and landings in line operation

Q 4.10 Do you think some pilots are just “lazy / too complacent” with regards to practicing manual flying?

- ❍ Strongly agree
- ❍ Agree
- ❍ Neutral
- ❍ Disagree
- ❍ Strongly disagree

Q 4.11 You are flying to a destination that you have previously visited and Air Traffic Control offers you a visual approach; the weather is nice and traffic levels are low. How would you most likely feel?

- ❍ Very comfortable
- ❍ Somewhat comfortable
- ❍ Neutral
- ❍ Somewhat uncomfortable
- ❍ Very uncomfortable

Section 5: Monitoring and Design

There have been several high profile loss of control accidents following low airspeed / high angle of attack / stall events. Some aircraft types have angle of attack information available to be displayed to the crew (e.g. it is available as a customer option on the Boeing 737NG & 777 and fitted to many new business jets).

Q 5.1 Do you think angle of attack information (alpha) should be displayed directly to the pilots on all public transport aircraft types?

- ❍ Strongly agree
- ❍ Agree
- ❍ Neutral
- ❍ Disagree
- ❍ Strongly disagree

Q 5.2 Should there be more audio and visual warnings from aircraft designers to alert of low airspeed situations?

- ❍ Strongly agree
- ❍ Agree
- ❍ Neutral
- ❍ Disagree
- ❍ Strongly disagree

Q 5.3 With regards to airspeed monitoring, do you feel it is easier to notice a large airspeed deviation from an EFIS "speed tape" type display, or from a traditional round dial "analogue" airspeed indicator? (In this case the original target speed was 250 knots).

- ❍ EFIS Speed tape
- ❍ Round dial

EFIS Speed tape

Analogue airspeed indicator

Q 5.4 If your aircraft is fitted with “trend vectors” on the primary flight display instruments; do you think this makes manual flight a lot easier?

- ❍ Strongly agree
- ❍ Agree
- ❍ Neutral / Not applicable
- ❍ Disagree
- ❍ Strongly disagree

Q 5.5 With some aircraft having full flight envelope protection with fly by wire/auto-trim, is there any benefit in practicing manual flight in these types, given that failures in equipment are rare?

- ❍ Strongly agree
- ❍ Agree
- ❍ Neutral
- ❍ Disagree
- ❍ Strongly disagree

Q 5.6 Do you feel that Autothrottle/Autothrust has changed the way you monitor your indicated airspeed?

- ❍ Less monitoring is required
- ❍ It has stayed the same
- ❍ More monitoring is required
- ❍ Not Applicable / Not fitted to my aircraft type

Q 5.7 Do you think monitoring skills are equally as important as good manual flying skills?

- ❍ Strongly agree
- ❍ Agree
- ❍ Neutral
- ❍ Disagree
- ❍ Strongly disagree

Q 5.8 Have you received from your operator any specific guidance with regards to maintaining or improving monitoring skills?

- ❍ Yes
- ❍ No

Q 5.9 In general, how would you perceive your fellow pilots’ monitoring skills are at the moment?

- ❍ Very good
- ❍ Quite good
- ❍ Average
- ❍ Could be better
- ❍ Poor

“If you wish to comment on this survey or to add anything with regards to manual flying skills, please feel free to comment below (max 3,000 characters). You have now reached the end of the survey. Thank you very much for your time and for your participation, it is really appreciated.”