

Department of Transport and Regional Development

Bureau of Air Safety Investigation

Advanced Technology Aircraft Phase Two

Interim Report



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ISBN 0 642 25069 3

June 1996

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ABBREVIATIONS

AFDS	Autopilot Flight Director System
A/T	Auto Throttle
ATC	Air Traffic Control
CRM	Crew Resource Management
CRT	Cathode Ray Tube
DME	Distance Measuring Equipment
ECAM	Electronic Centralised Aircraft Monitoring
EOD	End Of Descent
FAA	Federal Aviation Authority
FCU	Flight Control Unit
FLCH	Flight Level Change
FMA	Flight Mode Annunciator
FMC	Flight Management Computer
FMGS	Flight Management Guidance System
FO, F/O	First Officer
HDG SEL	Heading Select Function
ILS	Instrument Landing System
IMC	Instrument Meteorological Conditions
kts	knots
LCD	Liquid Crystal Display
LNAV	Lateral Navigation
LVL CHG	Level Change
MCP	Mode Control Panel
NM	nautical miles
NASA	Nation Aeronautics and Space Administration
SID	Standard Instrument Departure
SOP	Standard Operating Procedures
STAR	Standard Arrival Route
TCAS	Traffic Collision Avoidance System
V/S	Vertical Speed
VNAV	Vertical Navigation
VOR	VHF Omni Range

SYNOPSIS

The introduction of new technology to aviation has generally resulted in benefits to safety and efficiency, but has also resulted in a range of new human factors and operational difficulties. BASI's Advanced Aircraft Research Project began in response to a number of perceived problems, which included data entry errors, monitoring failures, mode selection errors and the inappropriate manipulation of automated systems.

For the purpose of this study, advanced technology aircraft, or automated aircraft, are defined as aircraft equipped with cathode ray tubes/liquid crystal displays and flight management systems, such as Boeing 737-300, Boeing 747-400, Boeing 777, Airbus A310, A320 and A340.

Phase 1 of this project included a literature review which identified the human factors of systems interface as a significant area for attention with advanced technology aircraft. Although advanced systems have the potential to reduce errors or be more error tolerant, they can also introduce new forms of error. NASA researchers have suggested that advanced systems have the potential to elicit more severe errors than electromechanical systems (Wiener 1989).

Previous international research has concentrated on the generic issues of automation. BASI believes there is a need to collect and disseminate information on specific operational problems, as well as the generic issues, relevant to advanced aircraft. Consequently the second phase of this project was begun.

The objectives of this research project were to:

- Determine specific types of human/system interface problems that are occurring on advanced aircraft in service within the Asia-Pacific region.
- Collect information on flight-deck errors.
- Assess the severity of errors.
- Identify design-induced errors.
- Identify areas where pilots inappropriately manipulate automated systems.

Information was collected by flight-deck observation and personal interviews with staff from three airlines in the Asia-Pacific region. Flight-deck observation was made on F50, BAe 146, B737-300, B767, B747-400, A320 and A330 aircraft. Four simulator sessions were observed on the A320, B747-400 and B777. Six personal

interviews were recorded with fleet managers and simulator staff. Observation of advanced technology aircraft in the air traffic control environment was carried out at the Sydney ATC Centre over a peak period of operation.

This information was used as the basis of a questionnaire which was tested during February and March 1996.

Ninety draft surveys, each comprising 65 questions (see appendix 1), were distributed through the flight safety departments of airlines in the Asia-Pacific region. Thirty-two survey forms were received by the specified reply date, representing a 35% return.

Each respondent was asked to complete a Survey Critique form which enabled the questionnaire to be evaluated and edited.

A range of safety issues were raised by crews during interviews and observation flights. Concerns were raised on subjects such as the role of ATC, training, workload, mode changes and the design of flight-deck controls.

This paper presents the views of a limited number of pilots and does not contain a detailed analysis of the results. The survey was well received by respondents and many useful comments on the content and layout were made.

INTRODUCTION

Definition

For the purpose of this study, advanced technology aircraft, or automated aircraft, are defined as aircraft equipped with cathode ray tubes/liquid crystal displays and flight management systems, such as Boeing 737-300, Boeing 747-400, Boeing 777, Airbus A310, A320 and A340.

Automation is the allocation of functions to machines that would otherwise be allocated to humans. Flight-deck automation, therefore, consists of machines which perform functions otherwise performed by pilots (Funk & others 1996).

Background

Accident, incident and anecdotal evidence indicates that the introduction of new technology to aviation has generally resulted in benefits to safety and efficiency (Norman & Abbott 1988), but has also resulted in a range of new human factors and operational difficulties. The Advanced Aircraft Research Project was begun in response to a number of perceived problems, which include data entry errors, monitoring failures, mode selection errors and the inappropriate manipulation of automated systems.

Phase 1 of this project included a literature review. This review identified human factors of systems interface as a *significant* area for attention with advanced technology aircraft. Although advanced systems have the potential to reduce errors or make the system more error tolerant, they can also introduce new forms of error. NASA researchers have suggested that advanced systems have the potential to elicit more severe errors than electromechanical systems (Wiener 1989). While reliability has not been a major issue with advanced systems, there have been occasional instances of system irregularities.

Previous international surveys have identified that although there is generally a positive view of new technology, some system interface difficulties are occurring with advanced systems. This is reflected in systems behaving in unanticipated ways, pilots inappropriately manipulating automated systems, and 'user errors'. Rather than laying the blame for these problems at the feet of pilots alone, it is useful to see such difficulties as *system-induced* abnormalities. *Although the term 'error' is used, it is not intended to imply that the focus of this interim report will be on individuals or organisations.*

The literature review identified major concerns with advanced aircraft, including pilot complacency, loss of skills and loss of situational awareness. Wiener (1989)

surveyed errors made by pilots of Boeing 757 aircraft and Wiener and others (1991) compared the DC9 with the MD 80, looking at errors in both aircraft types. James and others (1991) surveyed over 1,000 pilots on attitudes to advanced aircraft but focussed on *opinions* rather than *error types*. Lufthansa also surveyed A310 pilots (Heldt 1988) with an emphasis on opinion regarding cockpit layout and design.

Previous international studies have concentrated on the generic issues of automation.

The aim of phase 2 of this project is to identify potential pilot/system interface factors in advance of serious consequences. These areas of conflict are not necessarily being identified by existing government and airline safety systems for the following reasons: human factor incidents tend to be under-reported; there is often a resistance to reporting for fear of adverse consequences; and, perhaps most importantly, pilots may perceive errors as very minor, perhaps not recognising that they may be indicators of larger problems.

There is also a need to consider issues such as automation and long-haul flights.

BASI believes that aviation safety will benefit by the collection and dissemination of information on specific operational problems. Consequently, the second phase of the project was commenced.

Interim report

The purpose of this interim report is to record the results of several preliminary interviews with airline personnel, and to document the results of the trial phase of the Advanced Technology Aircraft—Safety Survey.

Scope

This interim report deals with the issues raised in face-to-face interviews with airline management and flight crews currently operating advanced technology aircraft. It includes the 'raw data' closed-question results of the trial of the Advanced Technology Aircraft - Safety Survey. This report does not contain a detailed analysis of the open ended questions contained in the survey.

1. OBJECTIVES

The objectives of the phase-2 study are to:

- Determine specific types of human/system interface problems that are occurring on advanced aircraft in service within the Asia-Pacific region.
- Collect information on flight-deck errors.
- Assess the severity of errors.
- Identify design-induced errors.
- Identify areas where pilots inappropriately manipulate automated systems.

2. METHOD

The information presented in this interim report has been collected through:

- Personal interviews with flight crew.
- Flight-deck observation.
- Personal interviews with airline management.
- Data collection through the Advanced Technology Aircraft—Safety Survey (see appendix 1).

Interviews with airline management and flight crew were conducted by a BASI research officer between October 1995 and January 1996. The information gathered during these interviews was used as the basis of a questionnaire. This questionnaire was then tested during February and March 1996.

Ninety surveys were distributed through the flight safety departments of two airlines in the Asia-Pacific region.

Thirty-two survey forms were received by the specified reply date, representing a 35% return.

Each respondent was asked to complete a Survey Critique form which enabled the questionnaire to be evaluated and edited before being distributed to the wider pilot population.

3. SUMMARY OF INTERVIEWS AND FLIGHT-DECK OBSERVATION

The following is a summary of information gathered between October 1995 and January 1996. This information was collected by flight-deck observation and personal interviews with staff from three airlines in the Asia-Pacific region. Flight-deck observation was made on the F50, BAe 146, B737-300, B767, B747-400, A320 and A330. Four simulator sessions were observed on the A320, B747-400 and B777. Six personal interviews were recorded with fleet managers and simulator staff. Observation of the ATC environment was carried out at the Sydney ATC Centre over a peak period of operation.

3.1 Air Traffic Control

- Some pilots reported that air traffic controllers are generally aware of the capabilities of advanced technology aircraft but do not use the full capabilities of these aircraft.
- Some pilots expressed a concern about the amount of data inputs required below 10,000 feet in the terminal area.
- A number of air traffic controllers reported that they are often restricted in the processing of advanced technology aircraft due to environmental and noise-abatement restrictions. One controller expressed a concern that the proposed change to record flight numbers instead of aircraft registration on flight data information will further restrict the use of aircraft capabilities: the controllers may not know what type of aircraft is operating a particular flight, and aircraft substitution may compound this problem.
- At some international locations, ground-based technology has not kept up with the development of airborne capabilities.
- Airline management expressed the concern that the greatest threat posed to the operation of advanced technology aircraft is the co-ordination of the airborne and ground-based systems.

3.2 Automation surprise

- Pilots ask why the technology is behaving in a certain way even after some years experience on a particular type.

3.3 Comparison

- Pilots generally expressed the opinion that, when comparing new and old technology, it is more difficult to operate the automated systems on new technology aircraft than the autopilot system found on older technology aircraft.

3.4 Design

- Some pilots did not like the design concept of non-moving thrust levers and controls. They were concerned with the loss of peripheral cues which they have accepted as necessary for the adequate control of their aircraft.
- Some pilots expressed the view that data-entry keyboards are not user friendly.
- Concern was expressed about the limitations of some control devices in turbulent weather. Some pilots considered that the general yoke design has not changed to suit changes in technology.
- On one aircraft type, the pilot is required to move the thrust levers rearward to engage manual thrust, then move the thrust levers forwards or rearwards to set the thrust required. Pilots reported that the initial rearwards movement of the thrust levers is contrary to normal instinct.

3.5 Mode changes

- Pilots confirmed that some mode changes occur without warning or adequate annunciation (e.g. Vertical Speed to Level Change).
- It was observed that not all mode changes are called or verified by operating crews. Operating procedures and philosophies vary between airlines operating the same type of aircraft.

3.6 Safety nets

- Pilots recognised that technology includes several safeguards against the input of incorrect data. These safeguards include preloaded data (company flight plans, approaches, runway data) and standard operating procedures.
- It was confirmed that it is possible to enter an 'end of descent' point that is lower than the airfield elevation, although these elevations are included in the database. Conceivably an LNAV/VNAV approach could be flown to this lower elevation; however, standard operating procedures do not allow VNAV coupling below 1,000 feet above ground level.

3.7 Skill loss

- Some pilots are concerned they may lose their basic flying skills through a lack of manual operation.

3.8 System workaround

- The requirement to 'trick' automated flight systems by the input of erroneous data has decreased. New version software has all but eliminated the requirement for system workarounds. However, the poor performance of some auto-throttle devices in maintaining a speed on descent, forces pilots to enter a lower speed to ensure some speed restrictions are not exceeded.

3.9 Traffic collision avoidance system

- Pilots agree that TCAS improves their situational awareness. However, some degree of automation fascination exists in some fleets with aircraft that are not all fitted with TCAS. ('Automation fascination' refers to the preoccupation of aircrew with new, or different, technology on the flight deck.) Situational awareness is decreased due to the pilot's preoccupation with this technology. This most often occurs within busy terminal areas where TCAS targets are most active.

3.10 Technology

- Some functions of the FMC/FMGS are not error tolerant. Some pilots reported that when some functions of LNAV and VNAV have been executed they are difficult to correct if an error has been made.
- Pilots must rely on independent navigation systems as most routes do not overfly ground based nav aids. For example, executing 'direct to' may cause previous waypoints to be overwritten. There is no 'undo' function if this is executed by mistake.
- Some pilots are concerned that SOPs do not include a standardised method of planning the EOD point. On non-FMC equipped aircraft, each pilot knew the standard EOD window (e.g. DME arrival); now each pilot programs the FMC/FMGS to achieve his own EOD. This may not be communicated effectively to the other crew members.
- Some software updates contain errors (waypoint co-ordinates errors).

- Some pilots reported that the FMC/FMGS keyboard/display is not user friendly. It does not conform to the QWERTY standard of a computer keyboard.
- Some pilots have lost situational awareness because they have not assimilated information available from the automated systems.

3.11 Training

- Only some training programs incorporate the discussion of accidents and incidents as a teaching tool.
- Pilots expressed the opinion that conversion from older technology aircraft to new technology aircraft is a 'big step'.
- Pilots would like a greater depth of knowledge about the aircraft systems before completing a conversion course.
- Some airlines teach a method of mode selections for various situations during simulator training which is then relaxed for line operations. This approach emphasises systems knowledge and the appropriate use of mode selections. Other airlines set strict guidelines which carry through from the simulator to line operations.
- Some pilots complained that training manuals present 'need to know' information. The 'nice to know' information, which in the past has led to a greater systems awareness, seems to have been overlooked.
- Generally, pilots would like more training on the use of the mode control panel/flight control unit before solo line operations. They agreed that the settling-in period was generally longer on new technology aircraft.
- Airline management expressed the view that progress through the training program largely depended on age and previous aircraft experience. They perceived that aircrew had a lower level of knowledge at the end of a course of training on new technology aircraft as compared to older technology aircraft. This is the result of systems training on a 'need to know' basis.

3.12 Unsafe acts

- One pilot admitted trying to reproduce aircraft configurations which have led to fatal accidents, or experimenting with unfamiliar modes during line operations. This behaviour was the subject of an editorial in *Aviation Week and Space Technology* (12 February 1996), which stated in part:

A recently trained pilot may work to expand his or her knowledge of the computer by trying out less familiar modes. The only problem is that pilots may be trying them out on a revenue flight with passengers on board...

3.13 Warnings

- Pilots have experienced some false warnings during flight.
- Not all instruments have warning flags and this can lead to confusion when cross-checking against similar instruments (e.g. standby altimeter).
- Pilots feel that the automatic computer diagnosis of system failures is not foolproof. While a computer may tell the pilot what the systems problem is, it may not direct the crew to a solution (e.g. resetting a circuit breaker).
- Some pilots mentioned that some warnings are subtle and easily overlooked.

3.14 Workload

- Pilots generally agreed that advanced technology aircraft do not alleviate fatigue. Workload is claimed to be physically easier but mentally harder. Workload is increased with heads-down programming below 10,000 feet and is increased in an abnormal situation.
- On aircraft which were 3-man crew, but are now 2-man crew (B747-400), the workload is higher because the captain always does the pre-flight inspection while the first officer does the work previously allocated to the flight engineer plus his own duties. Workload may be further increased if the first officer is required to communicate with ground staff. Some airlines are now attempting to overcome these difficulties.

4. SUMMARY OF SURVEY RESULTS

4.1 Criteria

- Ninety Advanced Technology Aircraft—Safety Surveys were distributed through the flight safety departments of two airlines in the Asia-Pacific region.
- Thirty-two survey forms were received by the specified reply date, representing a 35% return.
- Please note that questions 39, 49, 50, 51 and 52 were not answered by all respondents. They have therefore been intentionally omitted from these results.

4.2 Summary of results—open-ended questions

4.2.1

Part B—Question 11 On this aircraft, the automated feature I like <u>most</u> is:	This indicates the frequency with which the following categories were mentioned in the response. n = 32
LNAV / VNAV	13
COUPLE AUTO PILOT FUNCTIONS	9
FMC	6
AUTO THROTTLE	2
MCP / AFDS	1

4.2.2

Part B—Question 12 On this aircraft, the automated feature I like <u>least of all</u> is:	This indicates the frequency with which the following categories were mentioned in the response. n = 32
VNAV	9
AUTO THROTTLE	6
COUPLED AUTO THROTTLE	5
FMC FUNCTIONS	4
ADF/VOR NEEDLES ON EHSI	1
FAST/SLOW SPEED POINTER	1
MAP UPDATE FUNCTIONS	1
CRT SCREENS	1
MCP	1
INCORRECT SPEED/DRAW SIGNALS	1

Please note: No editorial changes have been made to the following written responses.

4.2.3

PART B—Question 13

Please describe in detail a mistake which you made, or saw someone make, which you think could be attributed to automation. Describe specifically what happened and why it happened.

- Sole reliance on VNAV PATH function with incorrect descent point. As a result of the incorrect information being loaded into the system the aircraft was high on descent profile. Raw data was overlooked.
- Attempted to fly the Melbourne runway 16 ILS, dated 19 January 1996 from Lizzy STAR. Workload too high. ILS procedure too complex. Support pilot must select 3 different radio aids in a very short period, i.e. the support pilot must tune FTH VOR, then select MEL VOR to track the lead bearing 352, then the 16 ILS. With the captain on the ILS frequency and the support pilot changing frequencies regularly the FMC did not update satisfactorily. LNAV was therefore drifting and thus no good.
- Wrong runway selected (Sydney 34L instead of 34R). Not really a problem because mistake was picked up straight away due to cross checking (company SOP's).
- The choice of whether to use LVL CHG or V/S mode on the MCP. Pilots often do not appreciate the inter relation with A/T and the rate of deceleration in LVL CHG mode, and how it will effect the descent profile.
- After avoiding weather in HDG mode, ATC clearance received for DIRECT TO a waypoint. FMC programmed and executed but LNAV not selected, probably due to lingering concern over storm avoidance. First Officer picked up error and advised the captain.
- Most common mistake observed is **the** lack of understanding of autothrottle modes and redundancy. If conducting a LVL CHG descent, sometimes some F/Os forget that the auto throttle then only has alpha floor protection. Therefore the company requires that during the approach an auto throttle speed mode must be active until on final.
- Several times I have witnessed the aircraft pitch to unusual nose down attitudes (usually in VNAV PATH with the auto pilot engaged) and the flying pilot has either been unaware of this or confused by the situation, resulting in slow, or no recovery.

- Departure from Sydney during a SID via runway 34 and a turn at 6 DME with altitude restriction of 5000 feet. The aircraft could not handle the subsequent climb, speed restriction, power change and pitch attitude. Instead of the pilot flying taking control of the aircraft he relied on the auto pilot too much. This resulted in a high pitch attitude and dramatic speed decay. Too much reliance on automation when it is out of the limits of the auto pilot systems can be dangerous.
- On base position for an ILS in IMC the flying pilot did not back up the auto throttle system with his hand. The aircraft captured an altitude but only one thrust lever advanced to maintain speed. A significant roll was developed and the autopilot disconnected
- In IMC and turbulent terminal airspace MCP speed and heading knobs too close together, i.e. during high workload mistakes can be made with these controls.
- FMC problems associated with lack of understanding of that system when new on type.
- A STAR incorrectly inserted (then not checked by both pilots) was executed, transition waypoint deleted, aircraft commenced diverging track.
- Incorrect cross checking of FMC cruise altitude vs MCP altitude. This resulted in VNAV climb capturing lower (and incorrectly set) FMC cruise altitude culminating in altitude infringement for 5 minutes.
- Incorrect descent profile. An end of descent (HEIGHT/DIST) had been entered into the FMC. The runway changed and without either pilot noticing the end of descent was lost when the new ILS was selected and executed. End of descent now became last height on STAR. Corrected by cross checking raw data (distance to run).
- A captain had entered an end of descent point of 210 kts at 15,000 feet instead of 210 kts at 1500 feet and had not verified it prior to executing. Consequently the aircraft overshot the descent point.
- Held high by approach control going into Los Angeles. Speed kept high at controller's request. Aircraft captured VNAV ALT and only by disconnecting autopilot and using heavy V/S and diving at approach end of runway was the approach and landing salvaged.
- Descending to an approach altitude than later cleared for approach. Got a little above the glide slope. the aircraft levelled off suddenly at assigned altitude and makes continuing approach very difficult.

- LNAV selected but failed to engaged, aircraft remained in HDG SEL. Eventually the aircraft was observed to be diverging from track and LNAV selected.
- FL 140 had been entered in the FMC. Aircraft was cleared to descend to FL 150. Aircraft flew straight through the assigned altitude and did not lock on to FL 150. Had to disconnect the autopilot and level the aircraft manually.
- At 70 DME we were asked to hold at 60 DME. By the time we had entered the data into the FMGC the aircraft had just overflown the 60 DME position. This confused the computer and the aircraft commenced a turn in the wrong direction.

4.2.4

PART B—Question 20

I am concerned about the Air Traffic Control procedures with the following geographical area.

SYDNEY	25
NOT CONCERNED / LEFT BLANK	2
BALI	1
INDONESIA	1
MELBOURNE	1
NOUMEA	1
PERTH	1

4.2.5

PART B—Question 21

Please outline a specific event where you had difficulty operating an advanced technology aircraft in accordance with an ATC instruction.

- Brisbane to Sydney. Too many last minute changes to descent. Instructions too complex e.g. '...turn left 250, descend to 4000, make pilot intercept of the 16L localiser, call established, reduce to approach speed, you are following...'
- Large changes required to speed (particularly slowing down) after commencement of descent profile.
- A speed reduction assigned by ATC after commencing descent with distance/height requirements incorporated into a STAR, consequently requiring unreasonable amounts of drag to achieve STAR height requirements.
- On pushback a late ATIS change advised. To avoid high programming load

before takeoff a Radar Departure was requested. This was refused due to application of noise restriction rules on the new runway. ATC did not seem to understand our cockpit management procedures.

- Late changes of runway prior to departure - programming time. Insane departures off Sydney 34L with altitude limits of 5000 until turning either east or west. Ridiculous non runway specific STARs at Sydney and refusal of ATC to advise runway for instrument approach until within 30 NM. Late requirements to reduce speed on descent and still be expected to meet altitude limitations.
- Late runway changes, and on occasions ATC do not seem to be aware they are giving a runway change. Difficulties experienced in this situation are not particular to advanced technology aircraft but can be compounded by them.
- Arriving into Sydney from Brisbane with various speed changes throughout the descent and then a height restriction at short notice, then a runway change within 15 NM.
- Sector Brisbane to Sydney, Approach advised of runway 16R ILS approach. About 20 NM reprogrammed for 16L. Insufficient time to reprogrammed FMC and check details, brief the approach and tune nav aids.
- On overshoot off an ILS in VMC due to the runway being occupied. To disable flight director when in approach mode requires you to turn off the FD or retune nav aids, and all this being done whilst handling power, flap, gear and turning to heading and levelling off at ATC instructed altitudes. This aircraft climbs very fast on two engines. You should be able to exit approach mode and have access to other modes at a press of a button.
- Transition from close base leg to a manual turn and final approach.
- Melbourne to Sydney, issued a STAR 250 NM from Sydney (RIV # Arrival), cross checked, briefed and entered in FMC. At top of descent ATC issued a new STAR (OAKDALE 2 Arrival). This required tracking off flight plan route, a complete brief, re-entering STAR in FMC. Most importantly this procedure has a more restrictive altitude at 20 NM. In this case the aircraft is already past the top of descent when the new STAR was issued. Manually initiated descent, profile correction is required while automatic side is reprogrammed. this happens on regular occasions to accommodate parachute dropping operations. It increases pilot workload at a time it should not.
- During taxi out revised ATIS required runway change. ATC have no idea how many items require resetting, recalculating, rechecking, briefing. the automatics

and company systems do not assist in the slightest. Must slow down and take it step by step to avoid oversight.

- Executing HDG SEL rapidly if HDG has not been backed up on bug.
- Cleared for STAR with crossing restriction. STAR cancelled. The expectation from ATC was to still maintain crossing altitude. Difficult to reconcile off path and ATC does not state restriction when STAR cancelled.
- An everyday, ongoing lack of consistency in Sydney ATC instructions.
- At Sydney ATC regularly ask us to reduce speed. This makes it difficult to achieve the height limitations associated with various Sydney STARs.
- On some occasions speed restrictions at the last minute with altitude requirements.
- Reaching a particular altitude before a certain distance to go.
- A320 has no VOR intercept function. On departure, when being radar vectored and given a pilot intercept you must use the HDG function to turn onto the radial. It is very easy to overshoot the radial.

4.2.6

PART B—Question 30

Please outline the details of a specific event where you had difficulty with Mode Selection, Mode Awareness or Mode Transitions.

- Attempting to intercept an ILS glide slope from above the slope, particularly if speed is excessive.
- After completing my conversion training I was still did not understand the relationship between V/S mode and the auto throttle.
- Attempting to remain in VNAV when leaving a holding pattern often causes difficulties, particularly when accelerating to 250 kts on exit. It is very slow in calculating new descent path so mostly FLCH mode is used.
- MCP speed and heading knobs are located too close together. Mistakes can be made when making selections in IMC and turbulent conditions.
- This system will revert if its parameter are breached. In some cases these parameters are set too fine. The parameters should be set to protect aircraft integrity and altitude integrity but should allow the pilot to determine whether

speed delay is acceptable. A warning would be more acceptable than a mode reverting automatically.

- After the initial phase of executing a go around I had trouble engaging climb thrust as it requires a different selection to the one normally made after takeoff.
- VOR/LOC mode should not be capable of being armed when the aircraft is not on an intercept heading.
- HDG SEL - there is no general turn mode other than Control Wheel Steering - ROLL
- En route climb from FL290 to FL330, V/S was used for the climb to FL330 and VNAV was not re-engaged on level off.
- Aircraft wanted to level out after take-off after the FMC was given a hard signal to specifically level (5000'). VNAV ACT annunciated instead of VNAV PATH. This was a PNF human error.
- Not cleared for approach until above the glide slope. LVL CH descent (idle power) selected. When the higher 'missed approach altitude' set, full power came in and climb initiated.
- On this aircraft, when in V/S mode, if the airspeed gets 5 kts below the selected speed the FMC defaults to LVL CH. You may not realise that the mode has changed. An audio chime that occurred with unselected mode changes would be an improvement.
- Use of speed brake.

4.2.7

PART B—Question 35

Please outline any specific event which caused you to question your position in relation to terrain, or other aircraft.

- Terrain warning due to heavy rain requiring mandatory 'pull up' even though conflict was not correct.
- Brisbane to Cairns, when being descended to radar lowest safe altitudes.
- On 16R in Sydney in visual conditions a late instruction from ATC to intercept the localiser resulted in the autopilot having to be disconnected to avoid going

through the centre line. A B737 was exactly opposite on 16L. Instructions should be given earlier.

- During radar vectoring in the Sydney control zone. Thunderstorms over the airport. Observed B767 at the same level. Advised of sufficient separation.
- On descent to Adelaide under radar control, the aircraft was descended to 3000 feet over high terrain associated with the Adelaide hills.
- BALI FIR - approaching runway 09 VOR/DME approach at DPS. ATC cleared three aircraft to KUTA intercept at the same altitude. Also cleared arrival from the NW through our level.
- Arriving into Cairns from the south via Innisfail NDB. The LNAV track was 2 to 3 degrees further west which took us a little closer to the hills at about 20 NM south of Cairns. Once out of the cloud I could see how close we were.
- Continued radar vectoring on downwind for runway 35 in Canberra for an ILS approach.
- During radar vectoring at Cairns or Canberra.

4.2.8

PART B—Question 40

Please outline the details of a specific event where you were required to 'trick' the FMC/FMGS by the input of false data.

- Below heights - enter a lower height.
End of descent point with suspect tailwind - load a slower than expected speed and enter a lower level tailwind on the descent forecast page.
- Unless a strong wind gradient exists I find the descent forecast page irrelevant and choose not to load it.
- Speed control in straight and steady flight or whilst in a slow descent with power off and at clean manoeuvre speed. 220 kts was set to achieve 210 kts actual speed.
- Melbourne to Sydney - strong westerly winds on descent. Had to make larger wind speeds on descent forecast page to maintain descent profile.
- Set lower altitude STAR to ensure aircraft makes requirements.

- To achieve below 8000 feet at 20 NM Sydney (STARs) I put in a point 2 NM before.
- On high speed descents using FMC SPEED, the aircraft can accelerate to a much higher speed, requiring selection of other modes to reduce speed.
- From south to intercept 01 ILS at Townsville, entered a lower speed to get aircraft to slow up for sharp turns onto final.
- Arriving at a gate e.g. 20 NM Sydney at or below 8,000 feet at 250 kts, one has to build a new waypoint in the FMC about 4 NM from the gate to achieve the correct speed at the gate.
- Maintaining 250 kts below 10,000 feet.

4.2.9

PART B—Question 45

Please explain how automation has affected your workload.

- Automation has released me to the point where more time can be spent on more efficient scanning/systems management/situational awareness.
- Reduces workload on SIDs/STARs/DME ARC etc.
- Allows more time to monitor.
- It presents a clear picture in the terminal area.
En route, assessment of options are much easier, altitude, fuel at destination, diversions etc.
- System reliability allow you to relax more in the cockpit and still stay ahead of the aircraft. Nervous energy is not wasted watching the automatics for errors.
- Allows me to concentrate another aspects of the operation - weather en route, alternates etc.
- Has shifted workload rather than change it, most often to our advantage but occasionally to our disadvantage.
- Has made life easier as most information can be supplied from the computer.
- Automation has increase the workload pre-departure, while the pilots are programming their flight profiles. During flight overall workload has decreased

and with proper profile planning can reduce workload below transition on descent.

- Automation has allowed more spare capacity/time to maintain a good lookout and to be able to devote more time to safe and accurate fuel/time PNR calculations and alternate planning.
- Much more preparation preflight and turn around.
- Makes flight management much easier.
- Reduces total workload by reducing navigational loads.
- Turn-arounds are busy for the F/O. Change of STAR increases workload.
- It allows you to make decisions with more information.
- Automation has reduced workload in areas and at times when workload was not high anyway. At times of high workload, the workload has increased due to automation.
- Additional cross-checking required.
- Where automation can be set up in advance, some of the pilot workload can be transferred to times of low workload. However, when last minute clearances are imposed, trying to program the aircraft to fly automatically rather than reverting to raw data can increase workload.
- Preflight, increased workload. Inflight, probably decreased. But we are in practical terms operating both an aeroplane and a computer system. They are not well enough integrated and inexperienced pilots forget to fly the aeroplane, too much interest in FMC.
- Helps to deal with high workload peaks. However, over all monitoring of the aircraft situation and auto modes is more demanding.
- For routine items, i.e. checklists, speeds, power settings, the workload is reduced.
- Automation has permitted greater situational awareness due to more time available to monitor the aircraft and systems.
- Workload is reduced considerably.

- Reduces workload of PF. Increases workload of PNF.
- Unchanged.
- Has made life more comfortable.

4.2.10

PART B—Question 60

What could be done to improve the training you received on this aircraft?

- Reduce talk level; in aircraft and minimise checklists.
- More training aids.
More training i.e. more exposure.
- More information at ground school can be like trying to pour 5 gallons into a 4 gallon drum. Biggest improvement can be gained in ensuring the quality of the training captain, e.g. that he/she has sound technical understanding of systems and operates the aircraft/systems exactly as specified in company operations manual.
- More effective demonstrations of the MCP modes and advantages/disadvantages. Demonstrations of particular situations and when one would use these modes.
- More face to face teaching during the ground school.
No back to back simulator sessions during the endorsement sessions.
More time to absorb information and also prepare for the next session.
- Perhaps a couple of extra classes presented by an operating pilot who could explain in pilot terms what each mode will do and when it is most appropriate to use each mode.
- More exposure of FMC/MCP functions.
- More face to face communication with instructors.
More hands-on work with FMC/MCP during fixed base simulator training.
More information on systems.
- More hands-on repetitive training than book work on FMS.
- More simulator time.

- More 'chalk and talk'.
- Make more time available for personal practice in the simulator to have a 'play' with the systems at your own pace.
- More in depth information on how the FMC calculates aircraft performance.
- Ongoing training needs improvement. Better use of simulators as practice aids and not straight checking. Practice with training captain or simulator instructor as against check rides where performance is logged. No opportunity to see what happens 'if'.
- More use of FMC trainer.
Additional hands-on flying in conversion.
Additional training in 'back to basics' backup.
- Home CD ROM and/or other PC package would assist in studying the manuals.
- Less emphasis on little things like verbiage used in procedures and more background of systems.
'Education' vs 'Training'.
- Hands-on FMC module with AFDS.
- Thorough training captain.
- More line training (sectors) would help to become more familiar with the various modes of operation.
The ability to simulate the ECAM functions (outside of the simulator) would be most desirable.

4.2.11

PART B—Question 61

Have you ever encountered an abnormal/emergency situation while flying your current aircraft (excluding simulator or base training)? If YES please describe the situation.

- Cracking of side window due to multiple cracking.
- Loss of both FMCs.
- Landing gear abnormal.
- Slat abnormal.

- Engine fire indication during climb, returned to airport.
- Engine failure.
- LE flaps transit light on during flap extension.
Numerous FMC failures.
- Engine fire warning on shutdown.
- Air/ground logic switch reverting to ground mode during cruise.
Engine shutdown due to overheat.
Hydraulic failure with manual gear extension.
- Engine failure.
- Generator failure.
- Double FMC shutdown.
Hydraulic system failure.
Electrical failure.
- FMC failure.
- Tyre and landing gear incident.
- Engine fire indication after landing.
- Loss of electrical systems.
- Rejected takeoff. An aircraft taxied onto the runway during take-off roll.
- Engine fire warning.
- Flaps locked resulting in flapless landing.

4.2.12

PART B—Question 62

Have you ever detected any FMC/FMGS data base errors (waypoint lat./long., SID or STAR route/restriction errors, etc?). If YES please describe errors.

- Inclusion of YMMB as an adequate airport for B737.

- SIDs have occasionally been incorrect in the data base supplied.
- Floating conditional waypoints and turning points on Sydney SIDs.
- Incorrect DME lat./long.
- Sydney SID - track and VOR radial did not agree.
- Company route SYD - CG1 contained error in legs. WMD instead of WLM.
- The waypoint did not exactly mirror the distance/radial.
- Height or speed restraints.
- BATES and SASSO (Sydney Terminal Area waypoints) do not appear to be on the runway 34L extended centreline.
- Company route (London–Bangkok) differed from ATC route on flight plan. If flown this would have caused an airways violation.
- Track did not agree with Melbourne 286 radial.
- Lat./long. of waypoints do not agree with raw data positions.
- Errors are common after data cycle changeovers.

4.2.13

PART B—Question 63

Did you discuss any advanced technology aircraft accidents or incidents during your training? If YES please list the accidents or incidents which were discussed.

- Adverse weather accidents involving the B737.
- Company CRM program covered numerous situations.
- Lauda Air B767 - inflight reverser deployment.
- A320 incidents/accidents.
- False updates and position shifts in FMC.
Controlled flight into terrain.

- Air Canada dead stick landing.
Air India A320.
- A320 accidents.
B747, Air France - Tahiti.
Airbus - Nagoya.
- A320 descending into terrain.
- A320 Strasbourg and Paris.

4.2.14

PART B—Question 64

What was the most difficult part of your conversion to advanced technology aircraft?

- Transfer of command inputs from manual intervention to automatic control.
- Dealing with raw data displays with automatic failures.
- Training too intensive, too compressed. Should be given more time to complete the task.
- Telling the 'box' to tell the aircraft to do something rather than telling the aircraft directly.
- Choice of the optimum MCP mode.
- Coping with all the information and applying it during the simulator sessions.
- The transition to new style instrumentation.
- Getting to know the FMC and MCP.
- Learning the specifics of mode changes and defaults used in automatic flight.
- Understanding the information available from the FMC/EFIS screen.
- Programming the FMC.
- Adapting to jet characteristics.
Learning descent profiles.
- Getting used to FMC operations.

- Learning to interpret the enormous amount of information available to the pilot.
- Use of the FMC/MCP.
- FMC.
- Finding the right balance of use between automated systems to reduce workload and raw data/manual flight where appropriate.
- Remembering to fly the aircraft.
- Use of the FMC and its integration into other systems.
- Flying a jet for the first time.
- Gaining a full understanding of the MCP/AUTO PILOT/ AUTO THROTTLE/ NAV SYSTEMS.
- Interpreting the FMA and CRT information.
- Lack of time flying the aircraft and simulator without the autopilot.
- Learning the modes and secondary effects of FMC operation.
- Initial transition to FMC/Glass.
- Use of FMC and integrated auto pilot.
- Ground school, particularly flight controls.

5. THE SAMPLE

5.1 Summary

- Thirty-two pilots responded to the trial survey.
- All subjects were male.
- This sample is a 'convenient sample'. Subjects were chosen by their respective airlines. Any employee who was on leave, or likely to be scheduled for leave during the trial period, was asked to be excluded from the potential sample group.
- No incentives were provided to any of the subjects to complete the survey form. Participation was on a voluntary basis.
- Participants were assured of confidentiality. This was achieved in the following way: the questionnaire did not require the subject to provide his/her name or address; no identifying codes were incorporated in the survey form; and each subject was provided with a free-post return envelope which was delivered direct to BASI.

5.1.1

Summary of flying experience

	Respond- ents	Average age (years)	Average hours on type	Average total aero- nautical experi- ence	Average number of sectors in last 90 days
Captain	19	42.78	3173.28	11,514.37	84.65
First Officer	13	41.03	3058.75	9,912.85	81.75

5.1.2

Summary of current aircraft type

Question 9—What aircraft do you currently fly ?	
B737/300-400	23
B767	6
B747/400	2
A320	1

6. DISCUSSION

The purpose of this interim report is to record the formulation and field trial of the Advanced Technology Aircraft—Safety Survey. This procedure included personal interviews with airline management and line pilots. Consideration was also given to past and present international research.

Thirty-two of the 90 questionnaires were returned. The total pilot population operating advanced technology aircraft in these two airlines is approximately 1,700.

The aim of the trial phase was to test the validity and clarity of the survey. On the basis of the Survey Critique, questions B16, B39, B49, B50, B51 and B55 were eliminated. Question B31 was reworked into two questions to differentiate 'en route charts' and 'instrument approach charts'. A question was included in the General section to assess flight crew alertness on automated flight decks.

The quality and quantity of feedback supported the evaluation and editing of the draft survey. However, this data is insufficient to allow any clear conclusions. The intention is to assess the results of this sample group against those of the wider pilot population. These results will be published in a forthcoming BASI report.

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APPENDIX 1



ADVANCED TECHNOLOGY AIRCRAFT - SAFETY SURVEY.

The Bureau of Air Safety Investigation, with the support of members of the Orient Airlines Association and its associated pilot representative groups, is conducting a research project into the 'Safety Issues of Advanced Technology Aircraft'.

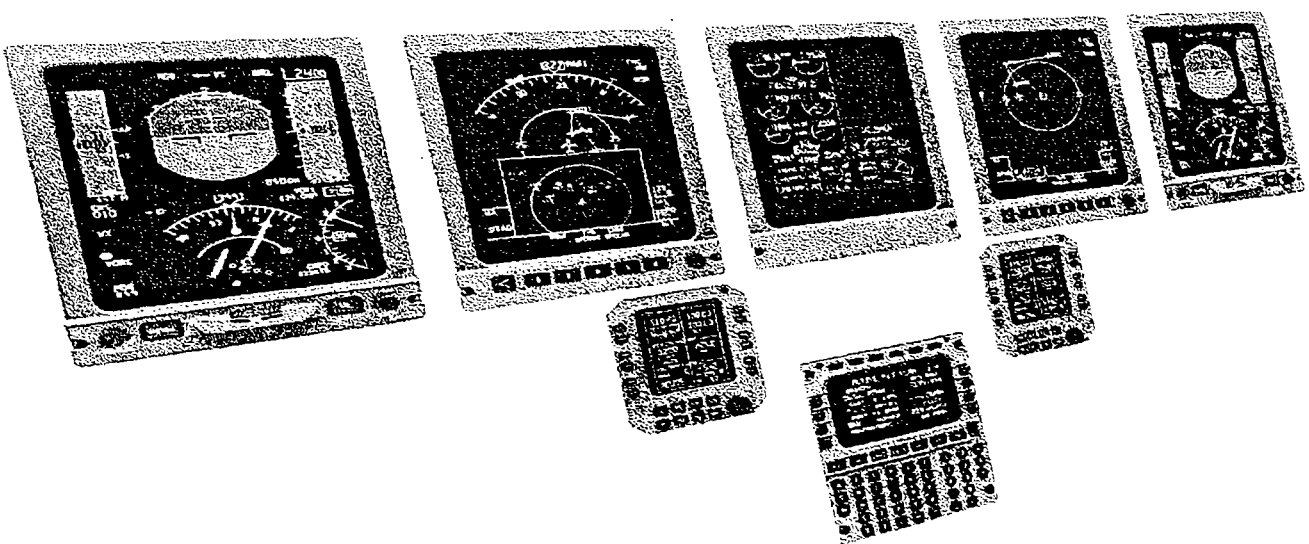
The aim of this project is to identify and rectify specific Safety Issues, which may compromise the safe operation of this class of aircraft. We are asking all aircrew of Advanced Technology Aircraft to take part in this important survey. By completing this questionnaire you will be assisting in cooperative research which will contribute to the development of safer operations.

As this survey does not require you to identify yourself, all information supplied is **COMPLETELY CONFIDENTIAL**.

It would be appreciated if you would complete this Safety Survey, **before Monday 11th March, 1996**, and return it using the attached prepaid envelope. The results of this project will be summarised in the Asia-Pacific Air Safety magazine.

If you have any specific questions regarding this research, please contact Peter Wiggins by telephone at 06 274 6460, Fax 06 247 1290, or E-Mail PWiggins@email.dot.gov.au

Thank you for your cooperation.



INTRODUCTION. PART A.

This survey contains 2 parts. **Part A** asks you to provide important information about your background and current position. **Part B** asks for your response to a number of statements.

IMPORTANT: For the purpose of this survey - **Advanced Technology Aircraft, or Automated Aircraft**, are defined as aircraft equipped with cathode ray tube/LCD displays and flight management systems, such as the Boeing 737-300, B747 - 400, B767 and Airbus A310, A320 and A340.

INSTRUCTIONS.

- a. Read all questions carefully.
- b. **TICK** the appropriate response. eg.
- c. Where written information is required, please write your answer within the box provided.
- D. In part A you may respond by ticking **MORE** than one box.

1. TICK the boxes which describe your position in the company.

- Captain
- First Officer
- Second Officer
- Cadet Pilot

- Management Position
- Check Pilot
- Training Pilot
- Supervisory Pilot
- Company Test Pilot
- Line Pilot

- Qualified
- Under Training

2. I fly **domestic routes** (flights which do not cross international borders eg. Sydney to Melbourne).
- international short haul routes** (flights to adjoining airspace eg. Australia to New Zealand, Singapore to Jakarta, Hong Kong to Taipei).
- international long haul routes** (flights crossing more than one international boundary eg. Manila to London, Tokyo to Los Angeles, Jakarta to Jeddah).

3. I am Male
 Female

4. My age next birthday will be

5. My nationality is
6. My first language is
7. My second language is
8. My home port (base) is
9. What aircraft type do you **currently** fly ?
10. When did you complete your engineering course/ground school for this aircraft ?
11. **Approximately** how many hours have you logged on your **current aircraft type**?
 hours.
12. What was your **previous aircraft type** ?
13. In what capacity did you fly that aircraft ?
 Captain
 First Officer
 Second Officer
 Cadet Pilot
14. **Approximately** how many flight hours have you logged (Total Aeronautical Experience) ?
 hours.
15. **Approximately** how many **sectors** have you flown as 'Pilot Flying' in the last 90 days? (A sector is a flight between any two points where you have conducted the take-off **and/or** landing.)
 sectors.

PLEASE CONTINUE WITH PART B.

**PART B
INSTRUCTIONS.**

a. Read all questions/statements carefully.

b. Please **TICK** only **ONE** response per question, e.g

Strongly Agree. *Agree.* *Neutral.* *Disagree.* *Strongly Disagree.*

Abbreviations

FMA - Flight Mode Annunciator, **FMC** - Flight Management Computer, **FMGS** - Flight Management Guidance System, **MCP** - Mode Control Panel, **FCU** - Flight Control Unit, **CRT** - Cathode Ray Tube, **LCD** - Liquid Crystal Display.

IMPORTANT

YOUR RESPONSE SHOULD RELATE DIRECTLY TO YOUR CURRENT AIRCRAFT TYPE, OR THE ADVANCED TECHNOLOGY AIRCRAFT YOU HAVE FLOWN MOST RECENTLY.

SYSTEM DESIGN AND AUTOMATION.

1. The FMC/FMGS and associated controls are 'user friendly'.

Strongly Agree. *Agree.* *Neutral.* *Disagree.* *Strongly Disagree.*

2. It is easy to detect when incorrect data has been entered by mistake.

Strongly Agree. *Agree.* *Neutral.* *Disagree.* *Strongly Disagree.*

3. I always know what the other crew member is doing with the automated systems.

Strongly Agree. *Agree.* *Neutral.* *Disagree.* *Strongly Disagree.*

4. On this aircraft, it is possible for both pilots to make control inputs via the control column or side stick at the same time.

Strongly Agree. *Agree.* *Neutral.* *Disagree.* *Strongly Disagree.*

5. They've gone too far with automation.

Strongly Agree. *Agree.* *Neutral.* *Disagree.* *Strongly Disagree.*

6. With automation there are still some things that take me by surprise.

Strongly Agree. *Agree.* *Neutral.* *Disagree.* *Strongly Disagree.*

7. The FMC/FMGS has sometimes failed to capture an altitude as I expected.

Strongly Agree. Agree. Neutral. Disagree. Strongly Disagree.

8. Incorrect data entered by mistake is easily corrected.

Strongly Agree. Agree. Neutral. Disagree. Strongly Disagree.

9. I sometimes find it hard to understand the language or technical jargon in messages presented by the FMC/FMGS.

Strongly Agree. Agree. Neutral. Disagree. Strongly Disagree.

10. I look at the FMA and MCP/FCU when I want to know what the aircraft is doing.

Strongly Agree. Agree. Neutral. Disagree. Strongly Disagree.

Please complete the following sentences in your own words.

11. On this aircraft, the automated feature I like most is;

.....
.....

12. On this aircraft, the automated feature I like least of all is;

.....
.....

13. Please describe in detail a mistake which you made, or saw someone make, which you think could be attributed to automation. Describe specifically what happened and why it happened.

.....
.....

If you require more space please continue your comments on page 12.

AIR TRAFFIC CONTROL

14. Air Traffic Control make use of the capabilities of this aircraft to their fullest.

Strongly Agree. *Agree.* *Neutral.* *Disagree.* *Strongly Disagree.*

15. Air Traffic Control appears to be familiar with the descent profile of my aircraft.

Strongly Agree. *Agree.* *Neutral.* *Disagree.* *Strongly Disagree.*

16. Air Traffic Controllers could benefit by taking observation flights.

Strongly Agree. *Agree.* *Neutral.* *Disagree.* *Strongly Disagree.*

17. Air Traffic Controllers sometimes ask for information which is difficult to extract from the FMC/FMGS in a reasonable amount of time.

Strongly Agree. *Agree.* *Neutral.* *Disagree.* *Strongly Disagree.*

18. The current level of Automation does not cope well with the last minute changes imposed by Air Traffic Control.

Strongly Agree. *Agree.* *Neutral.* *Disagree.* *Strongly Disagree.*

19. There is too much programming going on below 10,000 feet and in the terminal area.

Strongly Agree. *Agree.* *Neutral.* *Disagree.* *Strongly Disagree.*

20. I am concerned about the Air Traffic Control procedures within the following

geographical area:

21. Please outline a **specific event** where you had difficulty operating an advanced technology aircraft in accordance with an ATC instruction.

.....

If you require more space please continue your comments on page 12.

MODES

22. I always know what mode the autopilot / autothrottle / flight director is in.

Strongly Agree. *Agree.* *Neutral.* *Disagree.* *Strongly Disagree.*

23. It worries me that the automated systems may be doing something that I don't know about.

Strongly Agree. Agree. Neutral. Disagree. Strongly Disagree.

24. On occasion I have inadvertently selected the wrong mode.

Strongly Agree. Agree. Neutral. Disagree. Strongly Disagree.

25. Mode changes can occur without warning or adequate indication.

Strongly Agree. Agree. Neutral. Disagree. Strongly Disagree.

26. There are too many modes available on the FMC/FMGS.

Strongly Agree. Agree. Neutral. Disagree. Strongly Disagree.

27. There are modes and features of my aircraft that I still don't understand.

Strongly Agree. Agree. Neutral. Disagree. Strongly Disagree.

28. When it comes to mode selection, the company sets out clear guidelines and procedures.

Strongly Agree. Agree. Neutral. Disagree. Strongly Disagree.

29. A good crew briefing will always include what modes will be used.

Strongly Agree. Agree. Neutral. Disagree. Strongly Disagree.

30. Please outline the details of a **specific event** where you had difficulty with Mode Selection, Mode Awareness or Mode Transitions.

.....
.....

If you require more space please continue your comments on page 12.

SITUATIONAL AWARENESS.

31. I refer to my charts far less on new technology aircraft than on aircraft without an FMC/FMGS.

Strongly Agree. Agree. Neutral. Disagree. Strongly Disagree.

32. All the information I need for the safe conduct of the flight is contained within the FMC/FMGS.

Strongly Agree. Agree. Neutral. Disagree. Strongly Disagree.

33. I rely on Air Traffic Control to provide adequate terrain clearance.

Strongly Agree. Agree. Neutral. Disagree. Strongly Disagree.

34. At times I have been surprised to find the aircraft is closer to terrain than I thought.

Strongly Agree. *Agree.* *Neutral.* *Disagree.* *Strongly Disagree.*

35. Please outline any **specific event** which caused you to question your position in relation to terrain, or other aircraft.

.....
.....

If you require more space please continue your comments on page 12.

FLYING SKILLS AND SYSTEM SOFTWARE

36. I prefer to hand-fly part of every trip to keep my skills up.

Strongly Agree. *Agree.* *Neutral.* *Disagree.* *Strongly Disagree.*

37. My manual flying skills have declined since I started flying advanced technology aircraft.

Strongly Agree. *Agree.* *Neutral.* *Disagree.* *Strongly Disagree.*

38. I am sometimes forced to 'trick' the FMC/FMGS by entering erroneous data to achieve a desired result. (For example, I enter 240 knots to ensure the aircraft maintains 250 kts etc.)

Strongly Agree. *Agree.* *Neutral.* *Disagree.* *Strongly Disagree.*

39. Sometimes the 'cost index' forces me to adjust aircraft performance by entering erroneous data into the FMC/FMGS.

Strongly Agree. *Agree.* *Neutral.* *Disagree.* *Strongly Disagree.*

40. Please outline the details of a specific **event** where you were required to 'trick' the FMC/FMGS by the input of false data.

.....
.....

If you require more space please continue your comments on page 12.

WORKLOAD

41. Times of low workload in an automated aircraft are boring.

Strongly Agree. *Agree.* *Neutral.* *Disagree.* *Strongly Disagree.*

42. In an emergency, automated systems reduce my workload.

Strongly Agree. *Agree.* *Neutral.* *Disagree.* *Strongly Disagree.*

43. The introduction of automation has reduced the effect of fatigue during flight.

Strongly Agree. *Agree.* *Neutral.* *Disagree.* *Strongly Disagree.*

44. Automation does not reduce total workload.

Strongly Agree. Agree. Neutral. Disagree. Strongly Disagree.

45. Please explain how automation has affected your workload ?

.....
.....

If you require more space please continue your comments on page 12.

CREW RESOURCE MANAGEMENT AND SAFETY.

46. On this aircraft, the role of the pilot flying (PF) and pilot not flying (PNF) is always clear.

Strongly Agree. Agree. Neutral. Disagree. Strongly Disagree.

47. There have been times when the other pilot has not told me something I needed to know for the safe conduct of the flight.

Strongly Agree. Agree. Neutral. Disagree. Strongly Disagree.

48. Crew coordination is a problem on advanced technology aircraft.

Strongly Agree. Agree. Neutral. Disagree. Strongly Disagree.

49. This airline has an adequate incident reporting system.

Strongly Agree. Agree. Neutral. Disagree. Strongly Disagree.

50. At this airline, management encourages pilots to report incidents.

Strongly Agree. Agree. Neutral. Disagree. Strongly Disagree.

51. I would inform the company if I had a significant safety concern.

Strongly Agree. Agree. Neutral. Disagree. Strongly Disagree.

52. At this airline, management have a good awareness of the day to day issues faced by pilots.

Strongly Agree. Agree. Neutral. Disagree. Strongly Disagree.

TRAINING

53. Training for my current automated aircraft was as adequate as any training that I have had.

Strongly Agree. Agree. Neutral. Disagree. Strongly Disagree.

54. I would like to have a deeper understanding of the aircraft systems.

Strongly Agree. Agree. Neutral. Disagree. Strongly Disagree.

55. The most difficult aspect of my conversion was understanding the use of the MPC/FCU.

Strongly Agree. Agree. Neutral. Disagree. Strongly Disagree.

56. I sometimes have difficulty understanding information in the technical manuals associated with this aircraft.

Strongly Agree. Agree. Neutral. Disagree. Strongly Disagree.

57. I was able to find all the information I needed for my training in the aircraft/company technical manuals.

Strongly Agree. Agree. Neutral. Disagree. Strongly Disagree.

58. My training has prepared me well to operate this aircraft.

Strongly Agree. Agree. Neutral. Disagree. Strongly Disagree.

59. I prefer computer based training over traditional teaching methods.

Strongly Agree. Agree. Neutral. Disagree. Strongly Disagree.

60. What could be done to improve the training you received on this aircraft ?

.....

If you require more space please continue your comments on page 12.

GENERAL

61. Have you ever encountered an abnormal/emergency situation while flying your current aircraft (excluding simulator or base training) ?

YES NO

If YES please describe the situation.

.....
.....

62. Have you detected any FMC/FMGS data base errors (waypoint Lat/Long, SID or STAR route/restriction errors etc).

YES NO

If YES please describe these errors.

.....
.....

63. Did you discuss any advanced technology aircraft accidents or incidents during your training ?

YES NO

If **YES** please list the accidents or incidents which were discussed.

.....
.....

64. What was the most difficult part of your conversion to advanced technology aircraft ?

.....
.....

65. Further comments or suggestions.

.....
.....

Please attach extra pages if required.

THANK YOU FOR YOUR PARTICIPATION

IMPORTANT
PLEASE USE THE ATTACHED PREPAID ENVELOPE TO RETURN
YOUR COMPLETED SURVEY.
PLACE THE ENVELOPE IN ANY MAIL BOX WITHIN AUSTRALIA
BEFORE
MONDAY 11th March 1996.

APPENDIX 2



Advanced Technology Aircraft Safety Survey (DRAFT).

SURVEY CRITIQUE.

1. Were there any questions you **did not understand** ? Please list the question number(s) and comment further. You may like to write your comments against the question on the survey form.

.....
.....
2. What is your **general impression** of this survey (length, layout, readability) ?

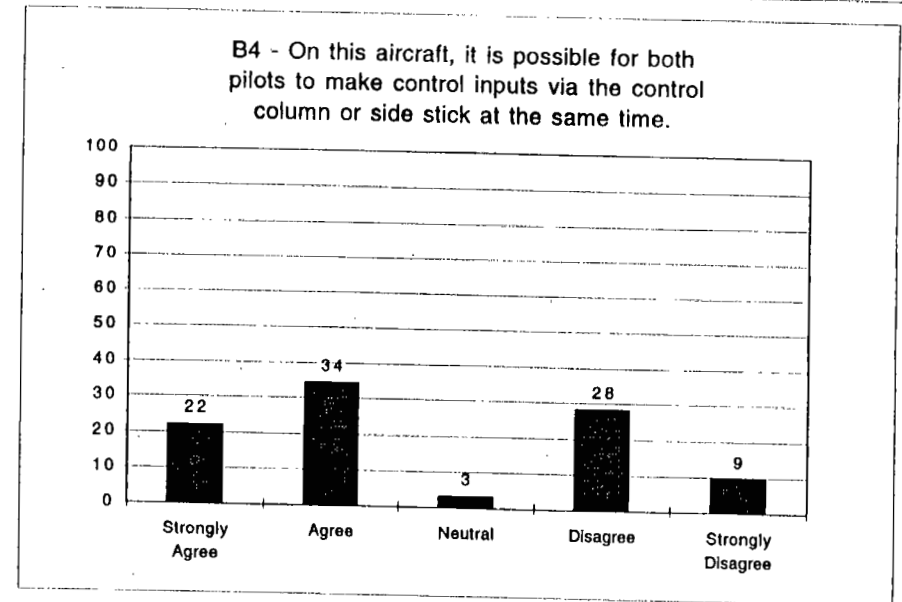
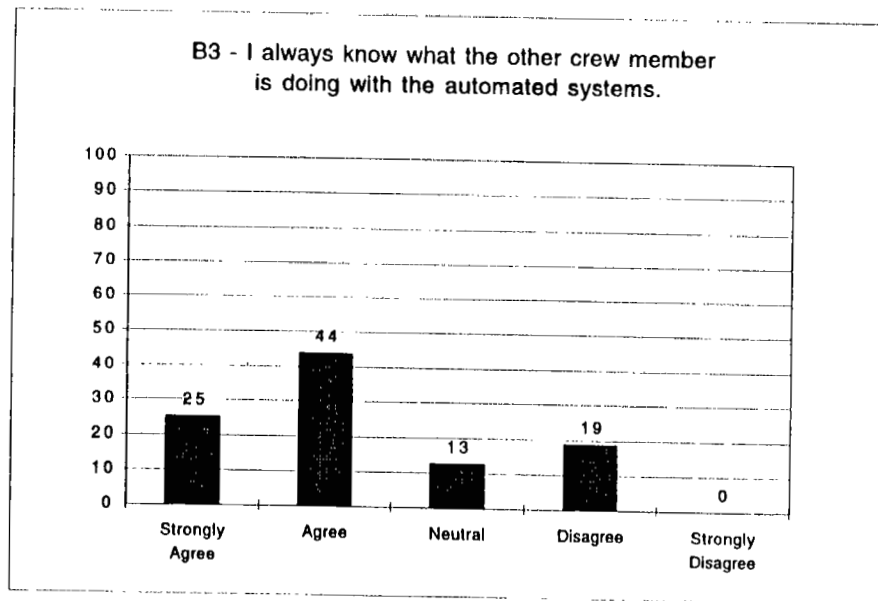
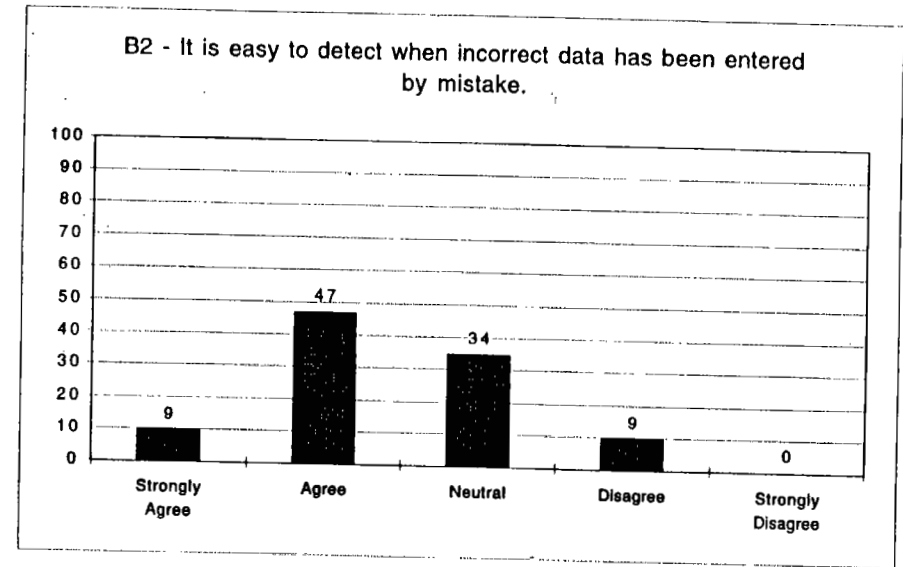
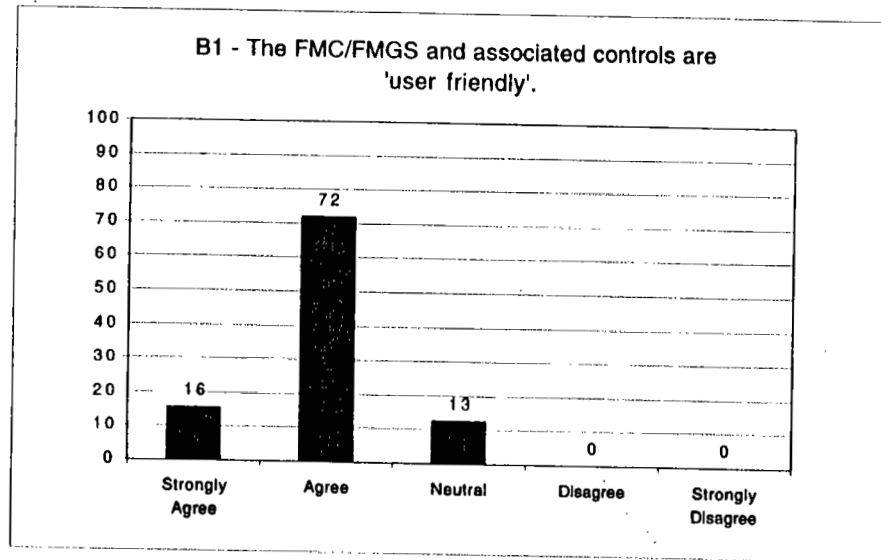
.....
3. Please list any topics which may have been **overlooked**.

.....
4. Please list any topics which should be dealt with in **greater depth**.

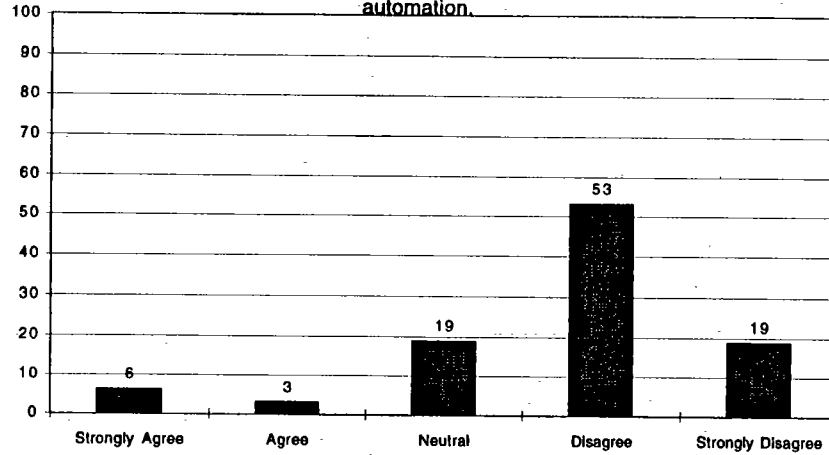
.....
If you have any specific questions regarding this research, please contact Peter Wiggins by telephone at 06 274 6460, Fax 06 247 1290, or E-Mail PWiggins@email.dot.gov.au

<p style="text-align: center;">THANK YOU FOR YOUR PARTICIPATION IMPORTANT PLEASE ATTACH THIS CRITIQUE TO YOUR COMPLETED SURVEY FORM. PLACE BOTH FORMS IN THE PREPAID ENVELOPE PROVIDED. PLEASE PLACE THE ENVELOPE IN ANY MAIL BOX WITHIN AUSTRALIA BEFORE MONDAY 11th March 1996</p>
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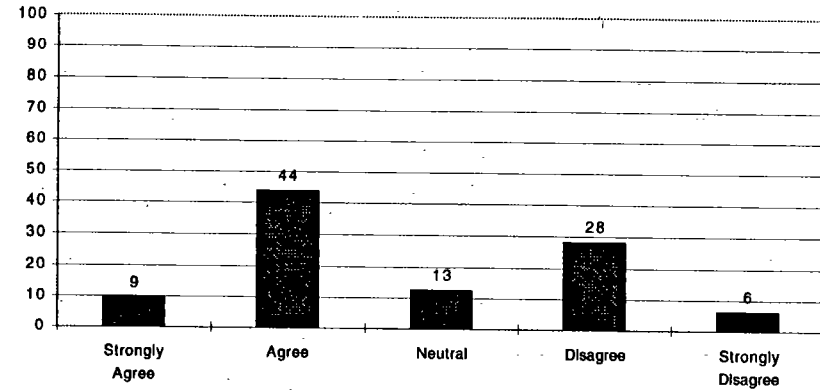
Appendix 3 Summary of results - closed questions part B



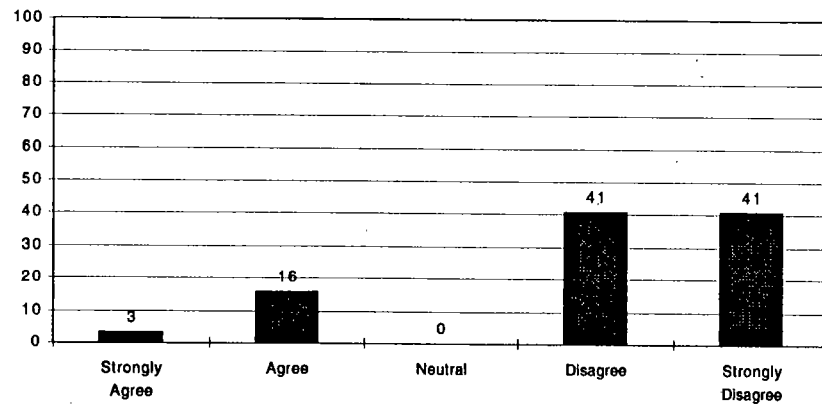
B5 - They've gone too far with automation.



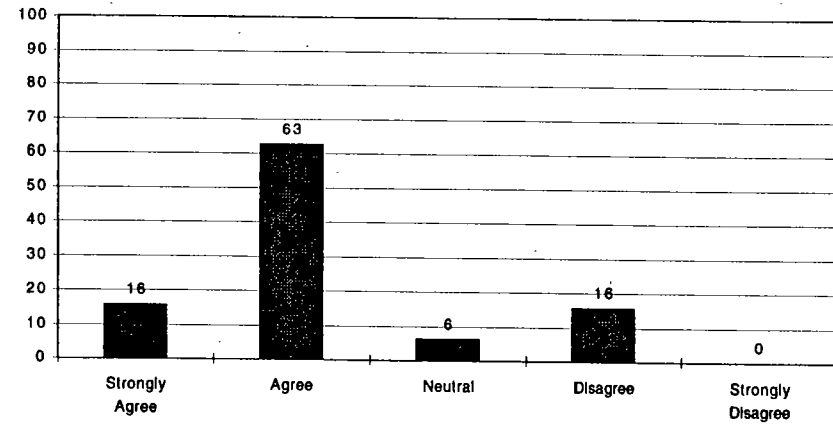
B6 - With automation there are still some things that take me by surprise.



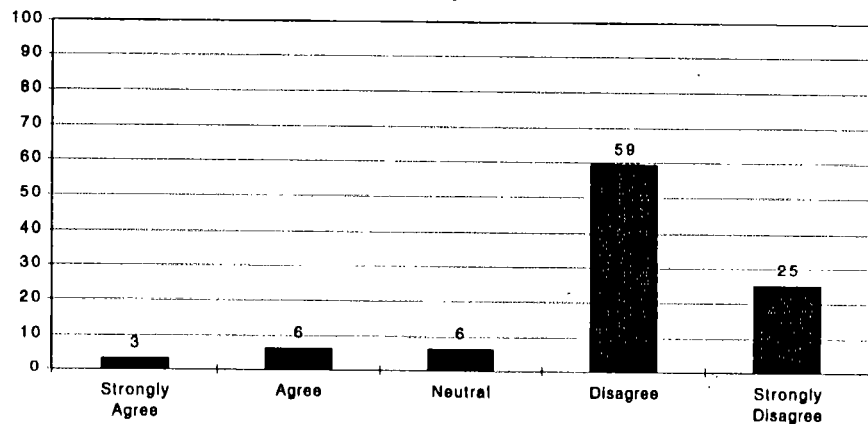
B7 - The FMC/FMGS has sometimes failed to capture an altitude as I expected.



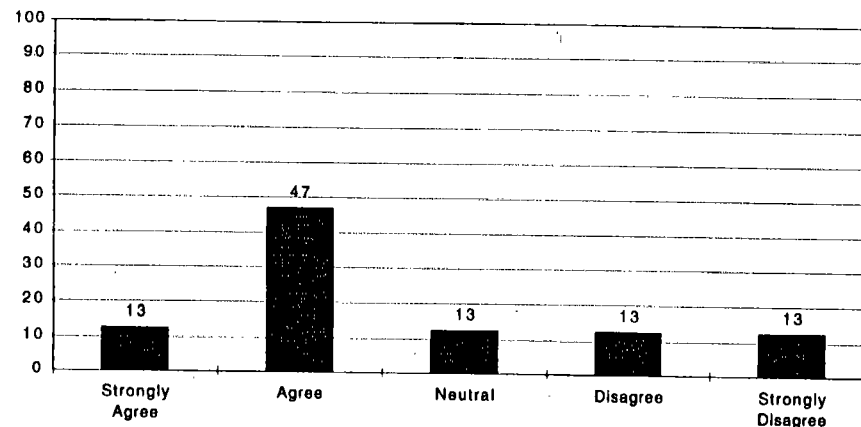
B8 - Incorrect data entered by mistake is easily corrected.



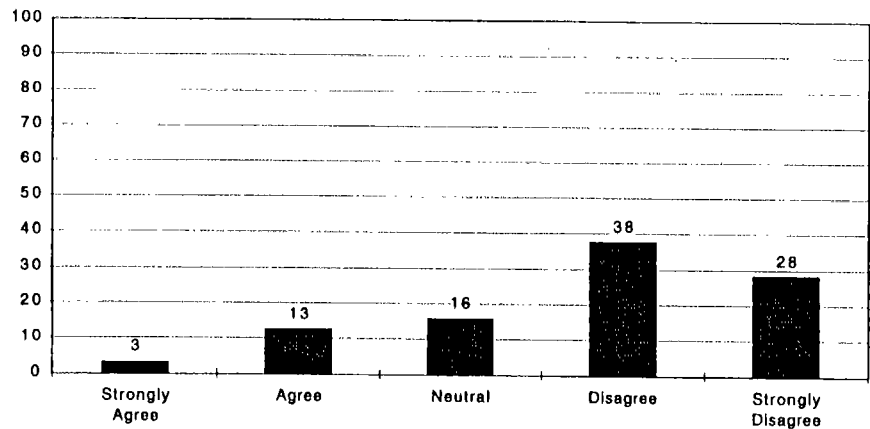
B9 - I sometimes find it hard to understand the language or technical jargon in the messages presented by the FMC/FMGS.



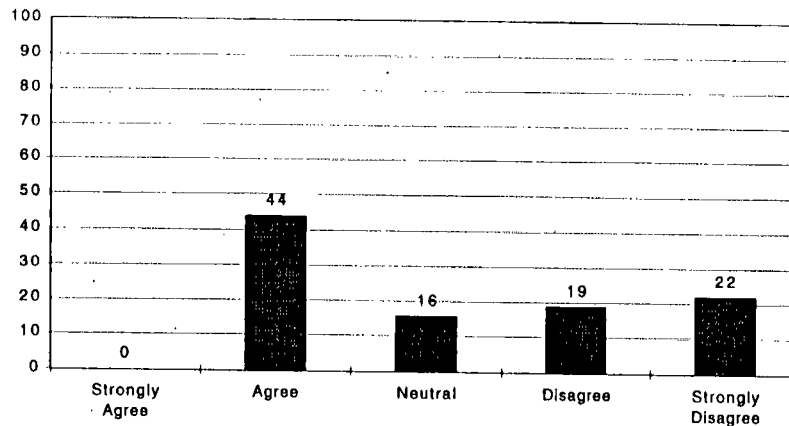
B10 - I look at the FMA and MCP/FCU when I want to know what the aircraft is doing.



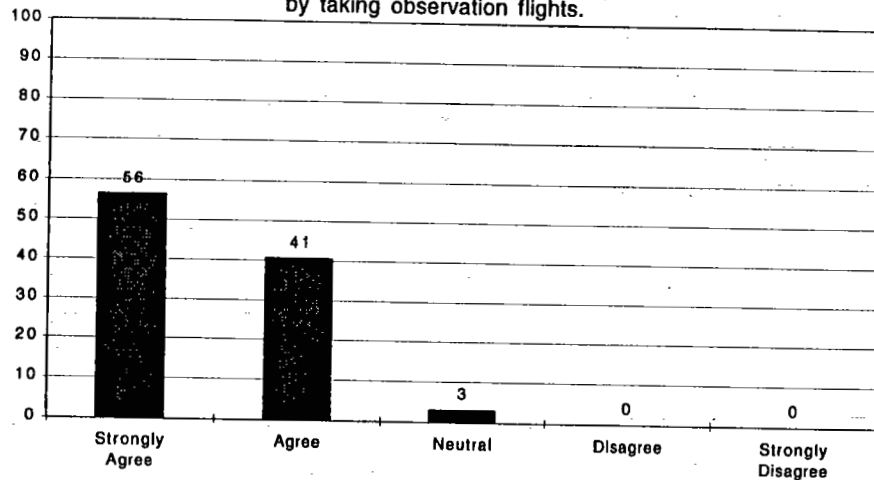
B14 - Air Traffic Control make use of the capabilities of this aircraft to their fullest.



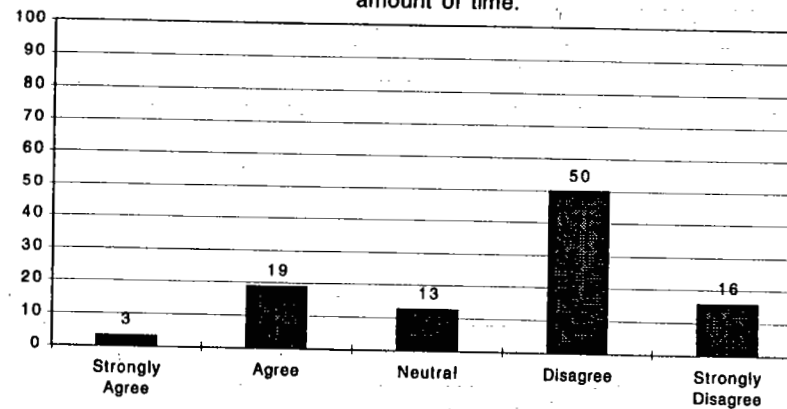
B15 - Air Traffic Control appears to be familiar with the descent profile of my aircraft.



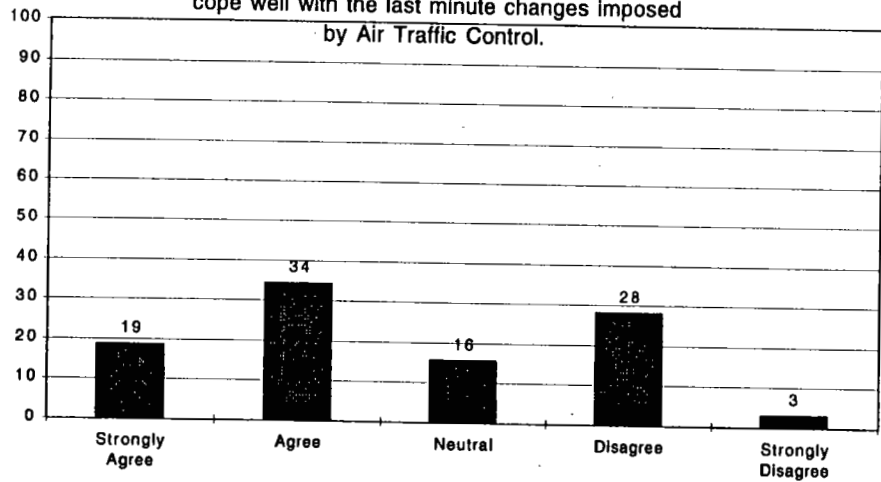
B16 - Air traffic controllers could benefit by taking observation flights.



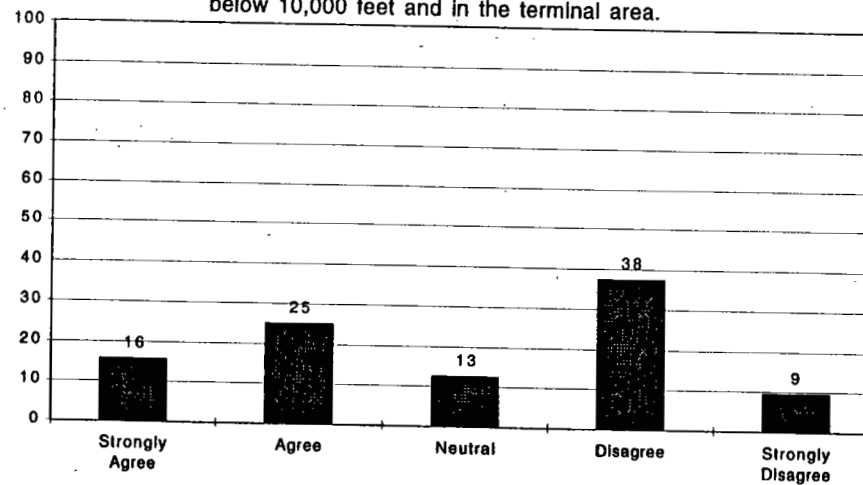
B17 - Air traffic controllers sometimes ask for information which is difficult to extract from the FMC/FMGS in a reasonable amount of time.



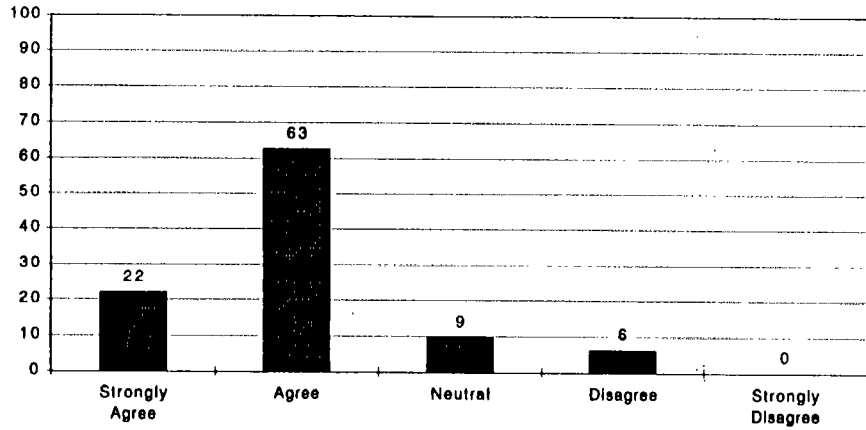
B18 - The current level of automation does not cope well with the last minute changes imposed by Air Traffic Control.



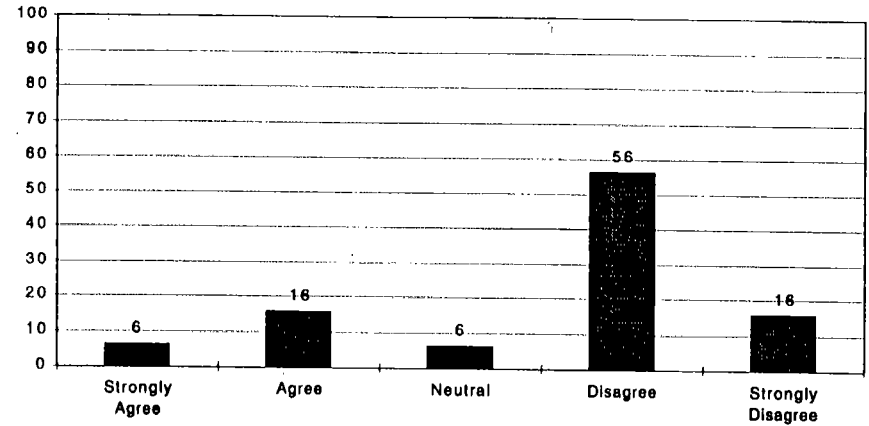
B19 - There is too much programming going on below 10,000 feet and in the terminal area.



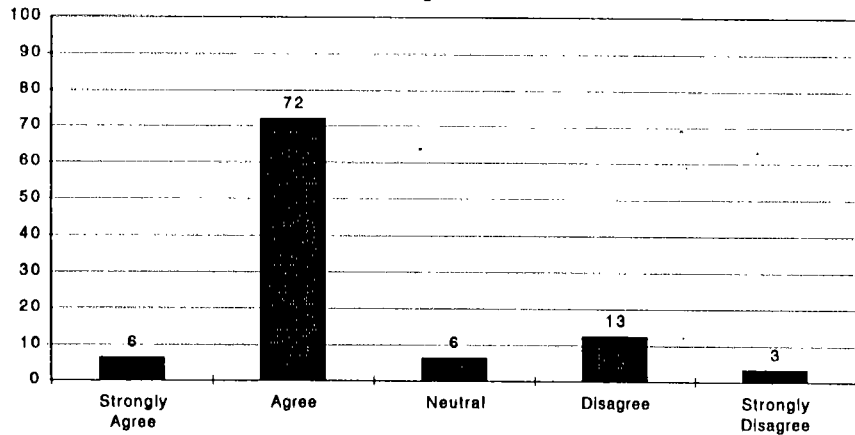
B22 - I always know what mode the autopilot/autothrottle/flight director is in.



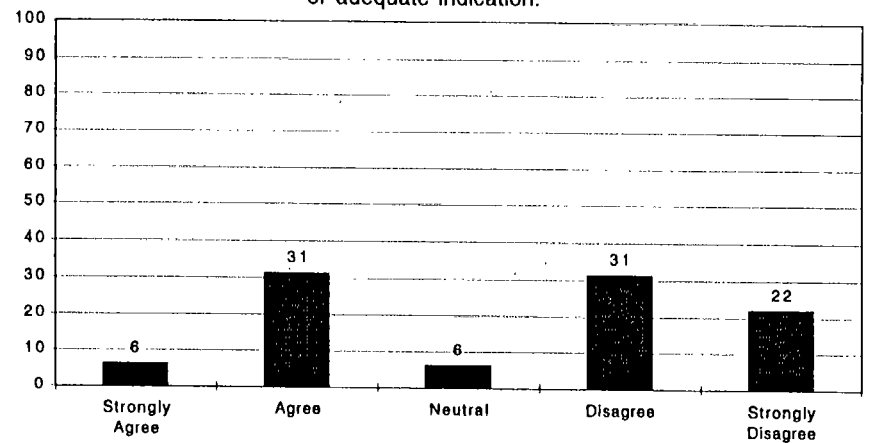
B23 - It worries me that the automated systems may be doing something that I don't know about.

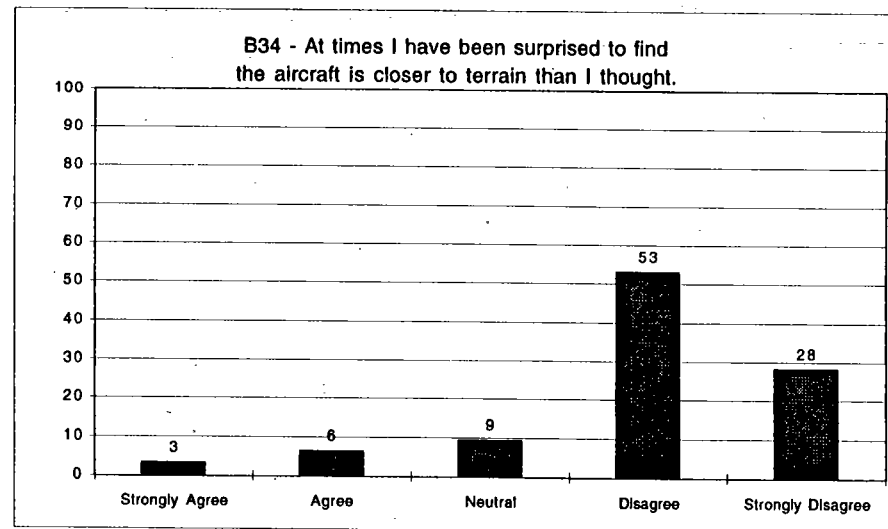
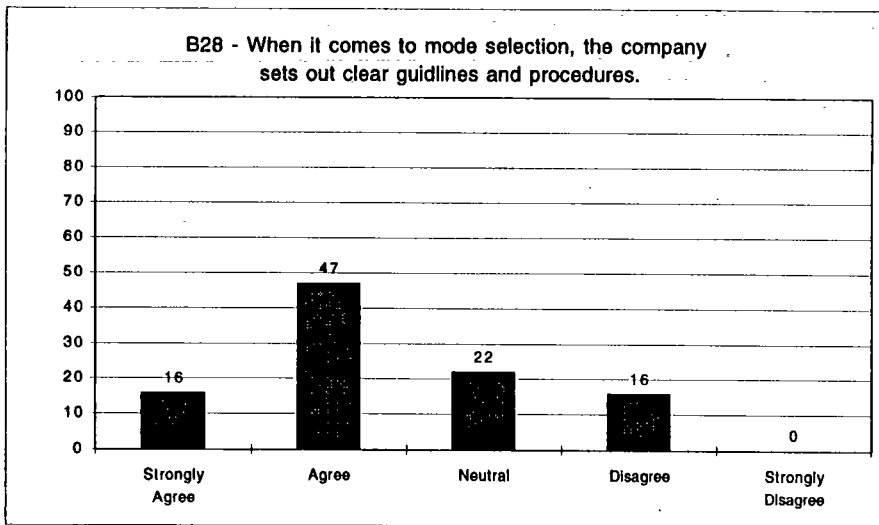
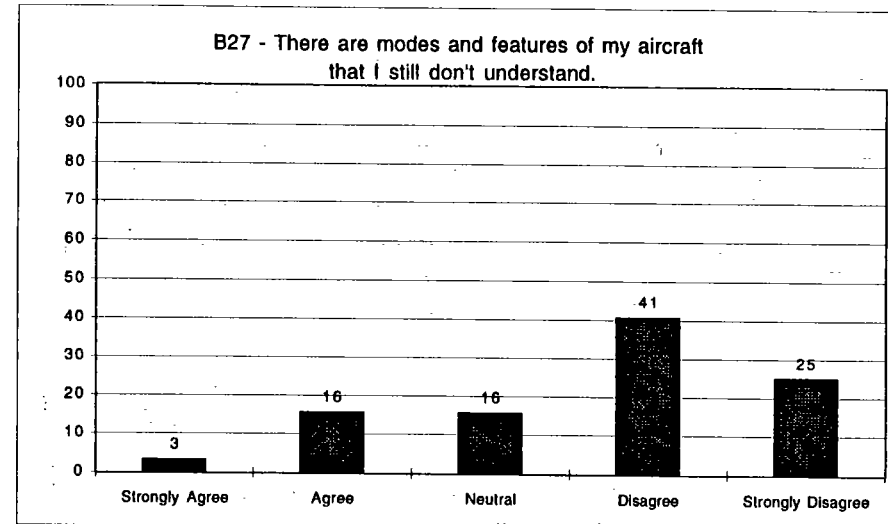
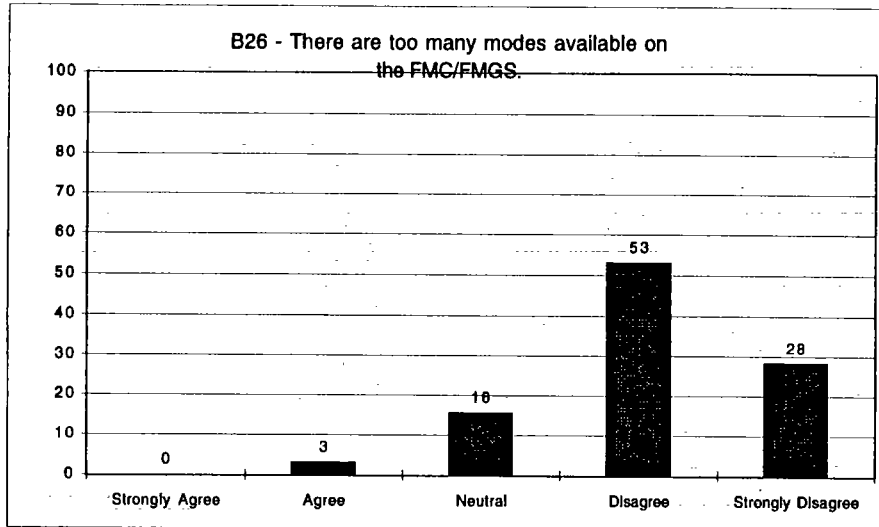


B24 - On occasions I have inadvertently selected the wrong mode.

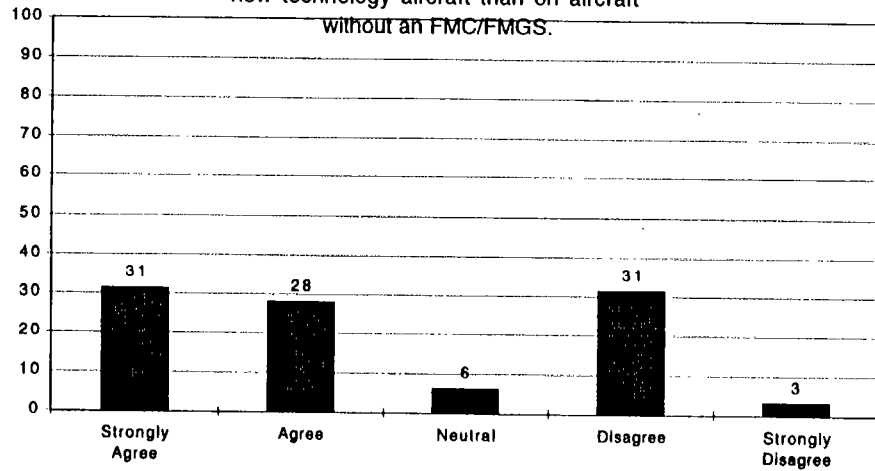


B25 - Mode changes can occur without warning or adequate indication.

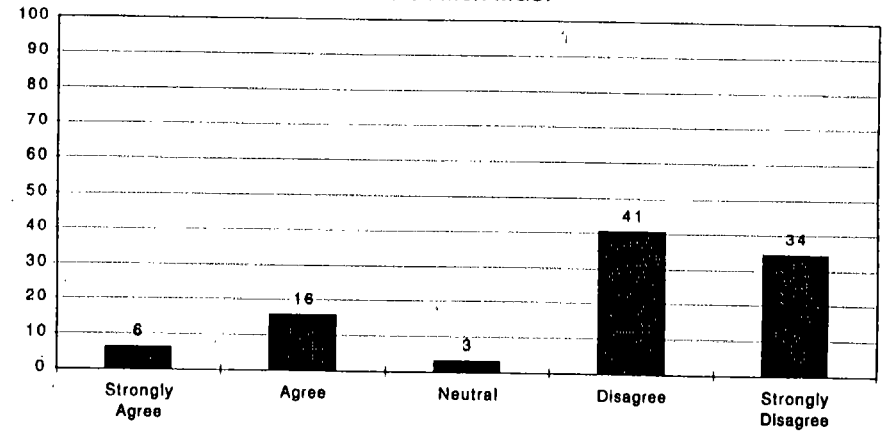




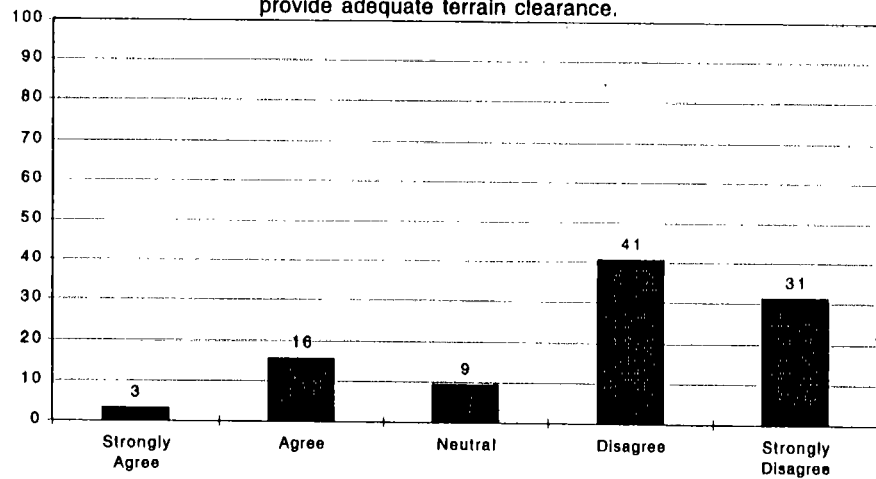
B31 - I refer to my charts far less on new technology aircraft than on aircraft without an FMC/FMGS.



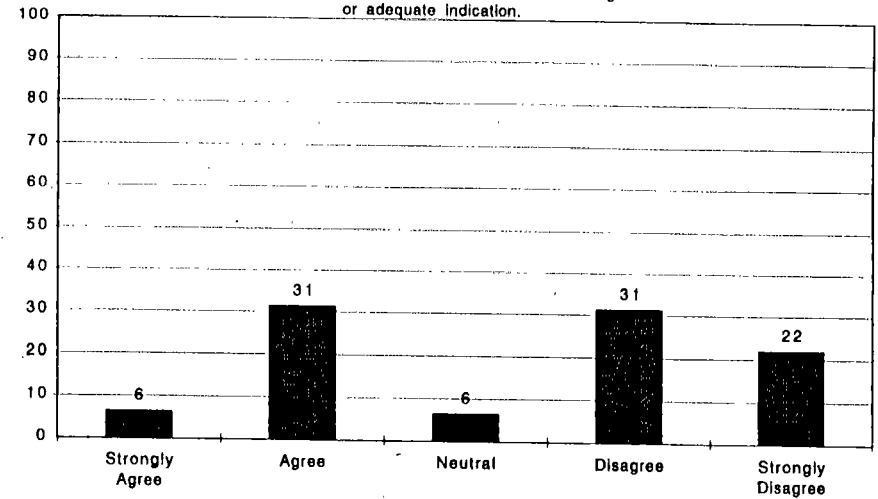
B32 - All the information I need for the safe operation of the flight is contained within the FMC/FMGS.

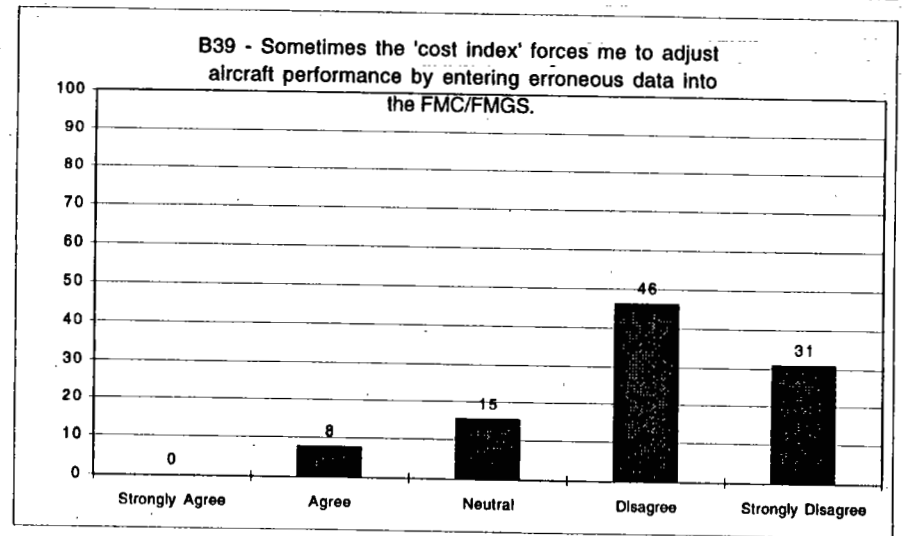
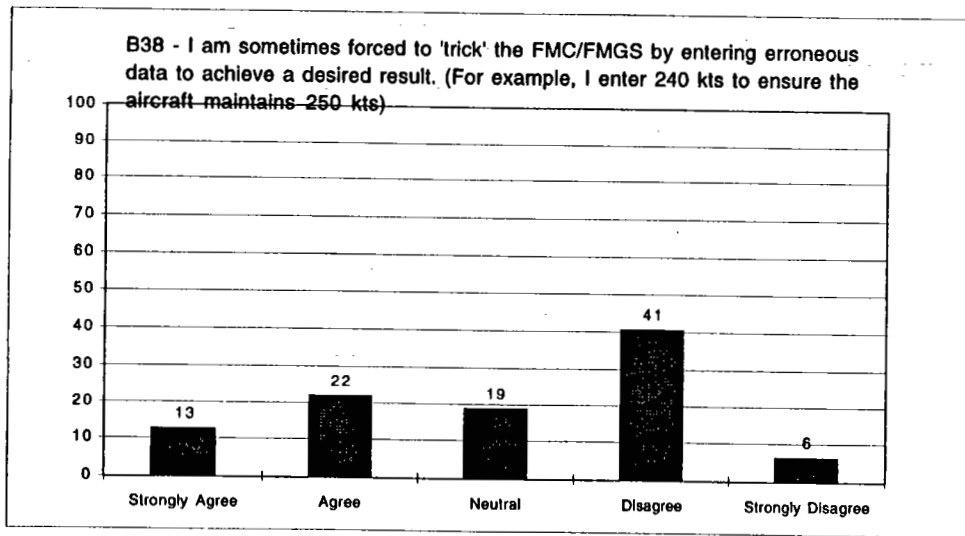
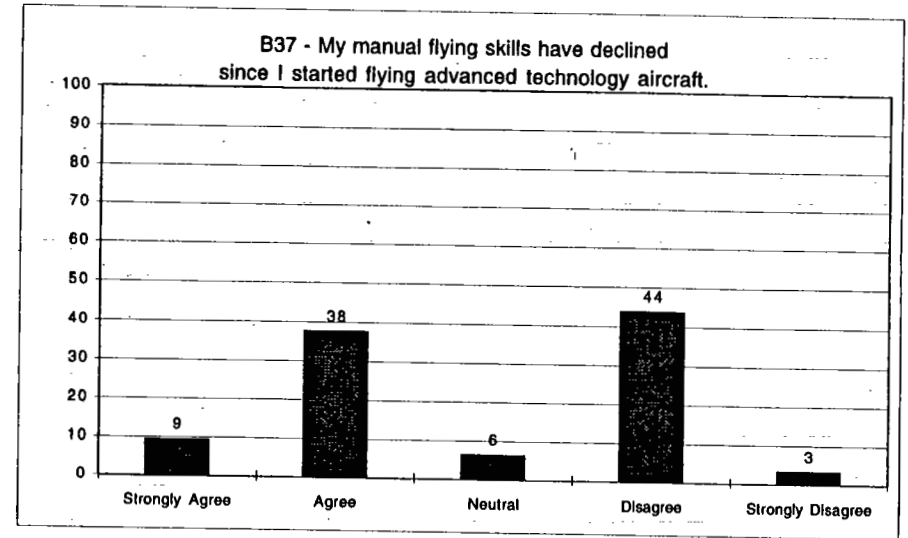
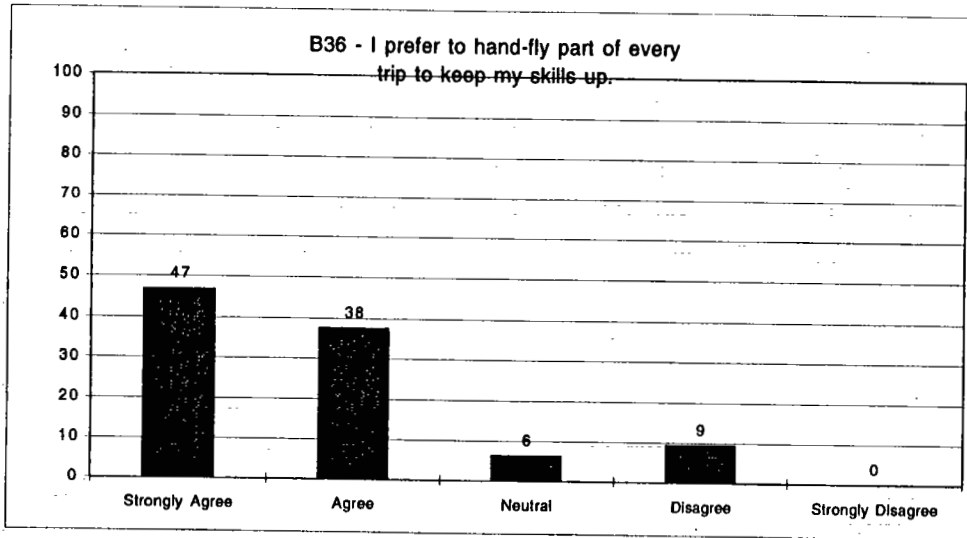


B33 - I rely on Air Traffic Control to provide adequate terrain clearance.

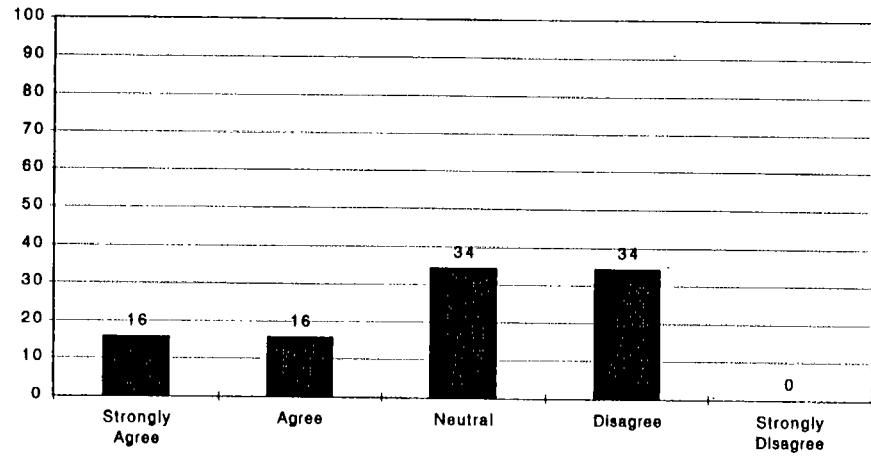


B25 - Mode changes can occur without warning or adequate indication.

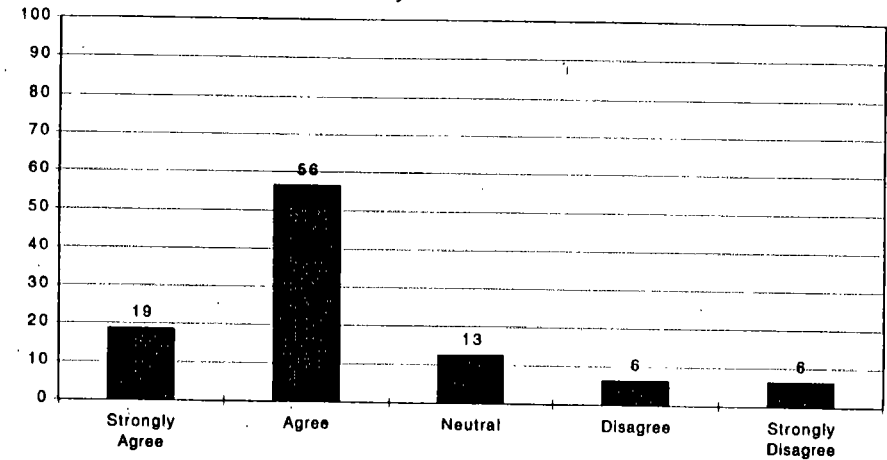




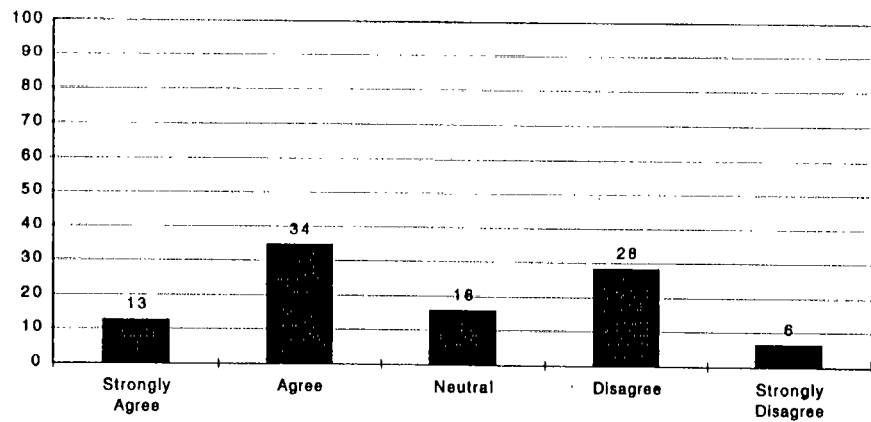
B41 - Times of low workload in an automated aircraft are boring.



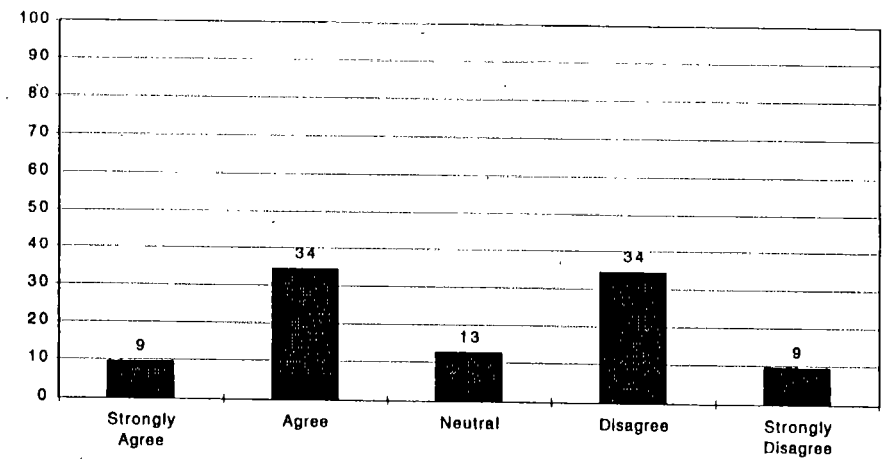
B42 - In an emergency, automated systems reduce my workload.



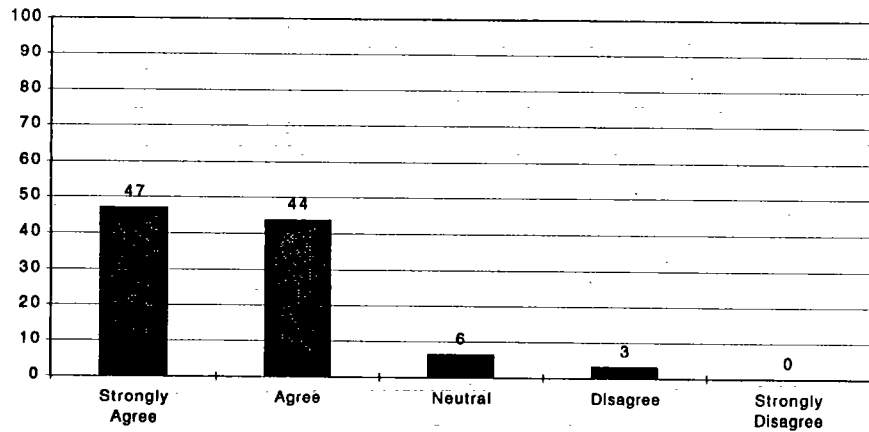
B43 - The introduction of automation has reduced the effect of fatigue during flight.



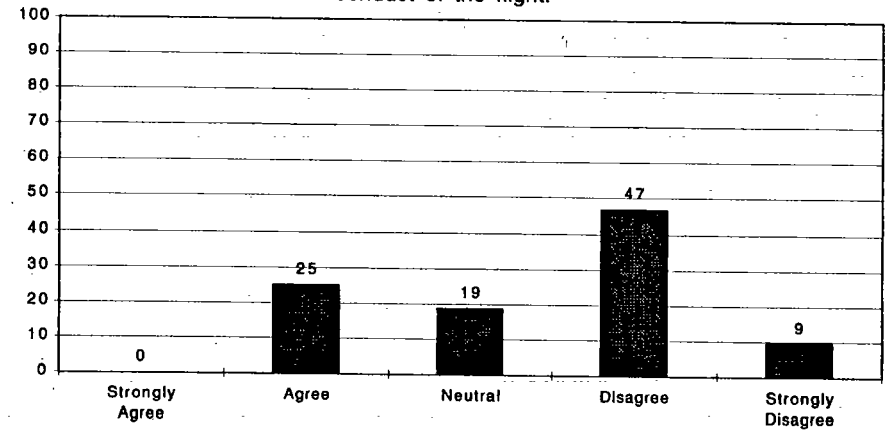
B44 - Automation does not reduce total workload.



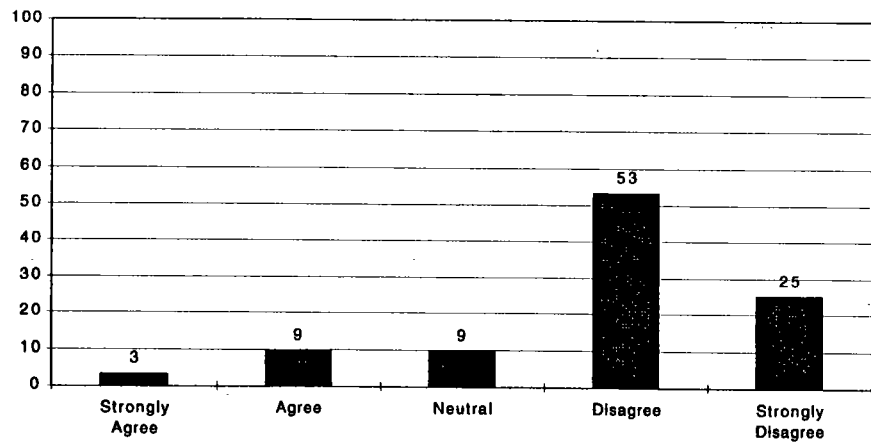
B46 - On this aircraft, the role of the pilot flying (PF) and pilot not flying (PNF) is always clear.



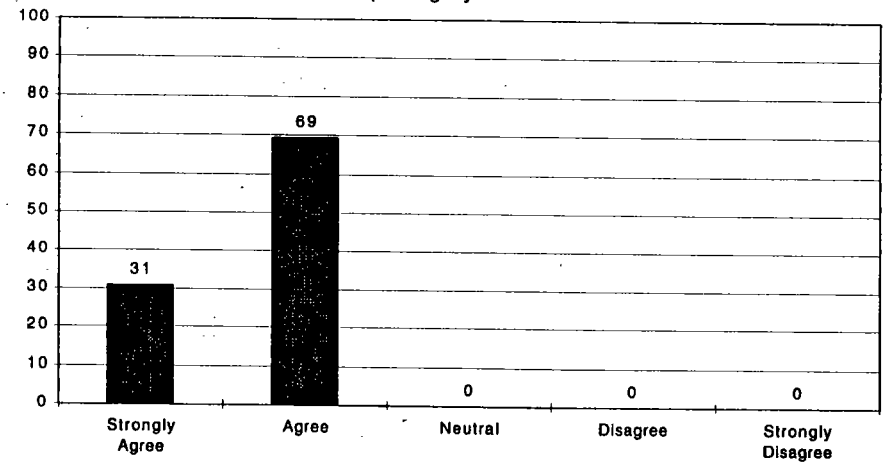
B47 - There have been times when the other pilot has not told me something I needed to know for the safe conduct of the flight.



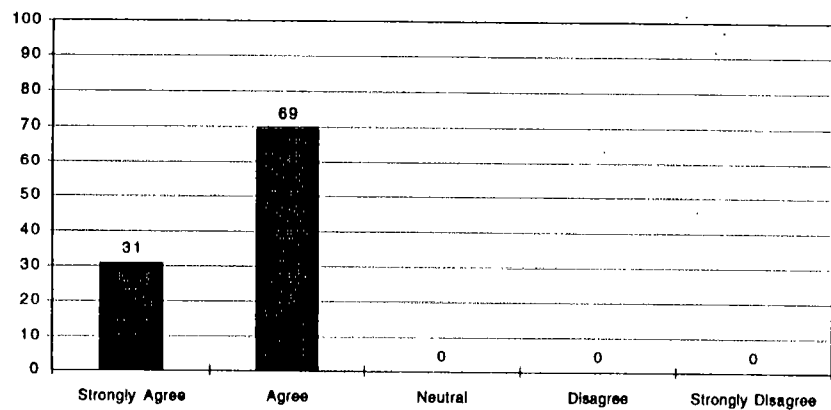
B48 - Crew coordination is a problem on advanced technology aircraft.



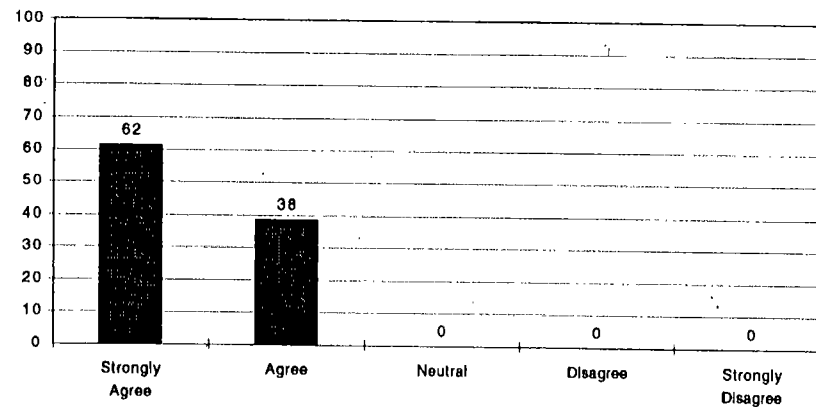
B49 - This airline has an adequate incident reporting system.



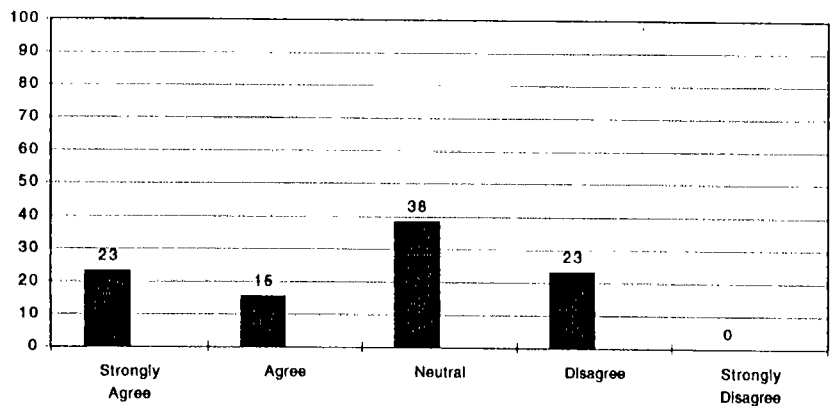
B50 - At this airline, management encourage pilots to report incidents.



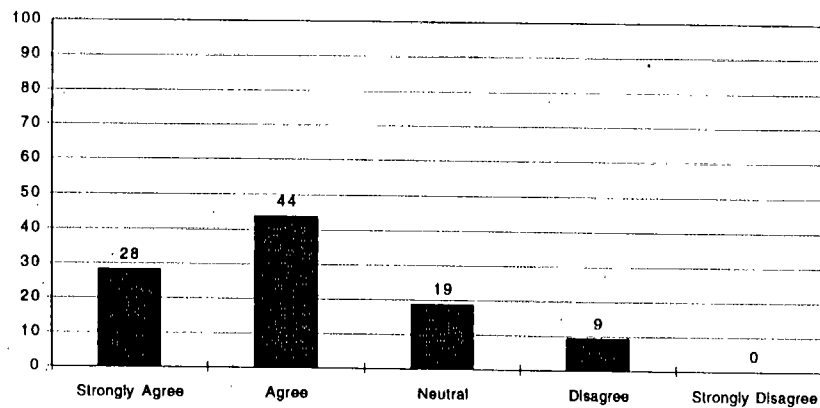
B51 - I would inform the company if I had a significant safety concern.



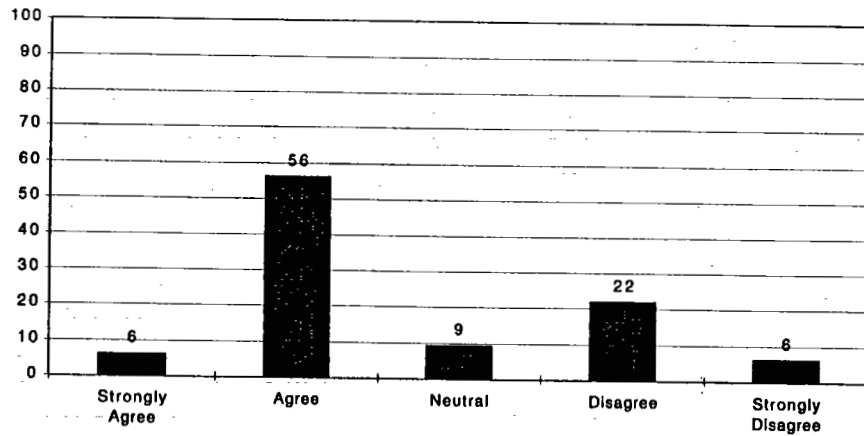
B52 - At this airline, management have a good awareness of the day-to-day issues faced by pilots.



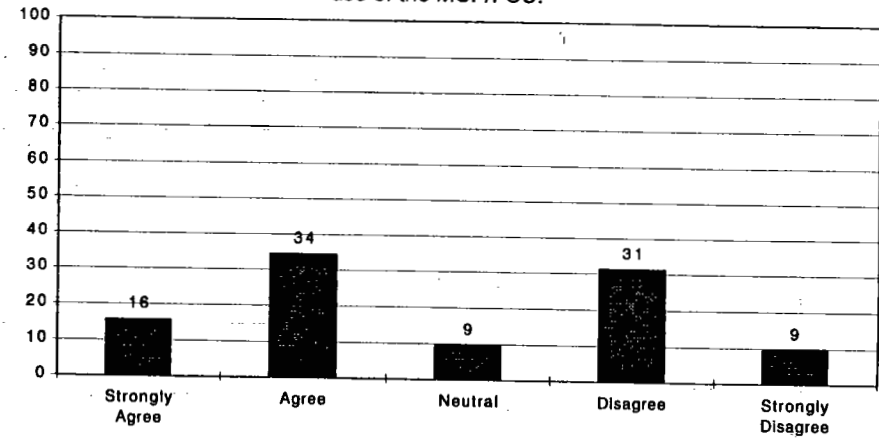
B53 - Training for my current aircraft was as adequate as any training.



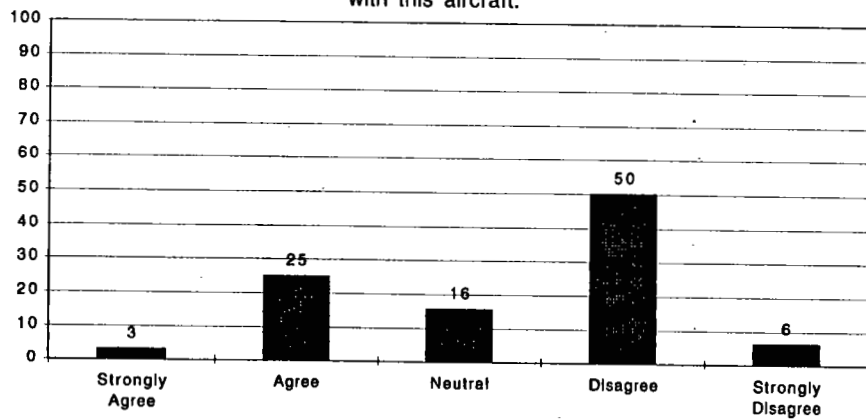
B54 - I would like to have a deeper understanding of the aircraft systems.



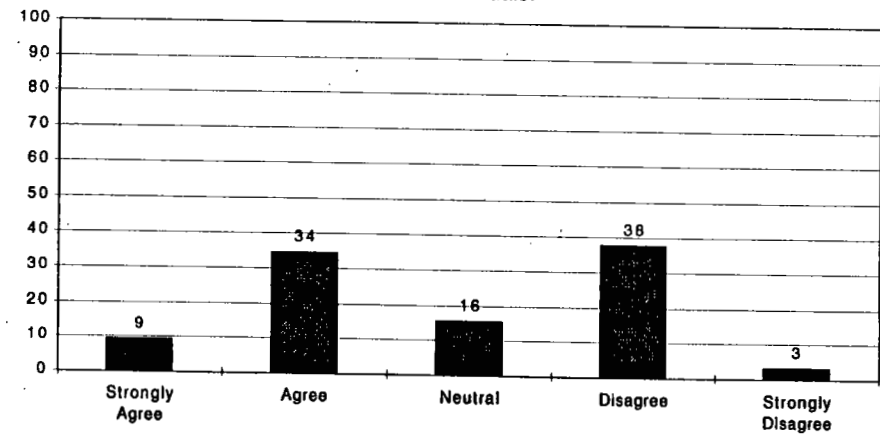
B55 - The most difficult aspect of my conversion was understanding the use of the MCP/FCU.

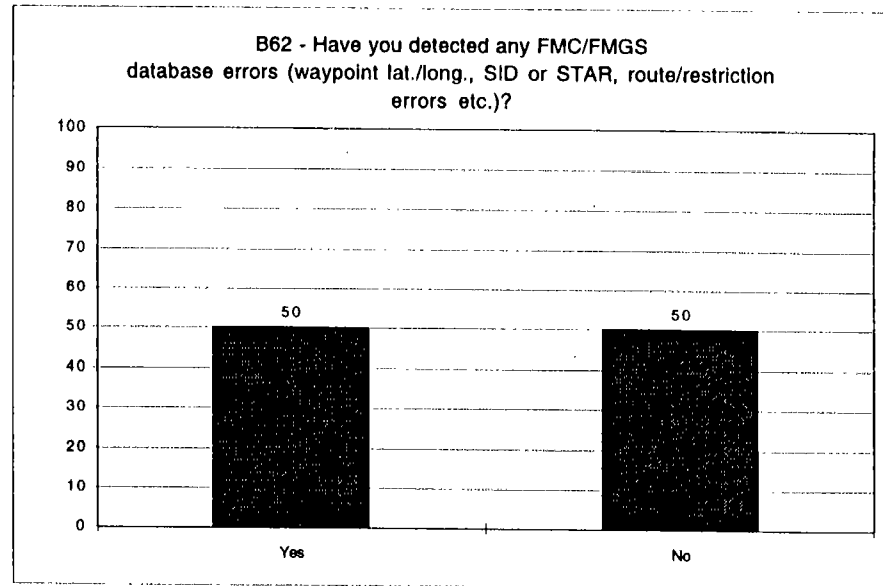
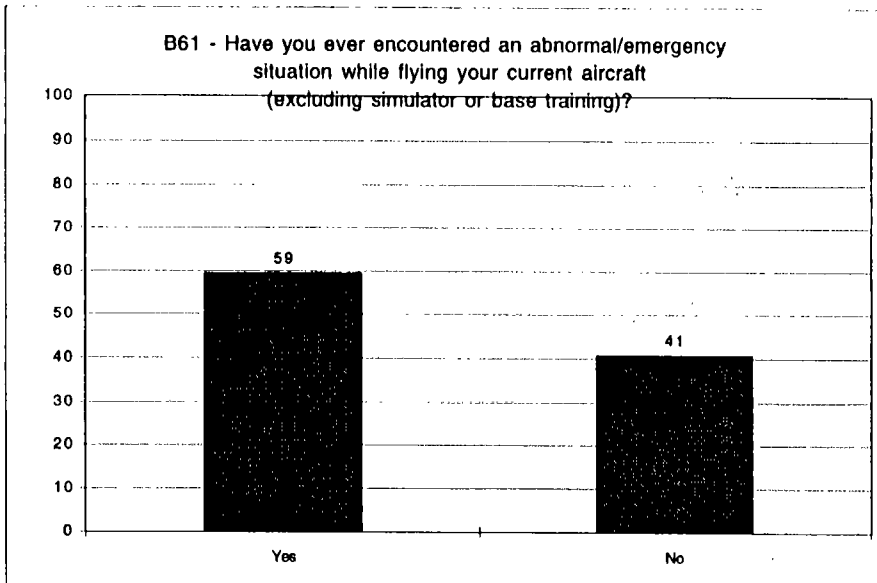
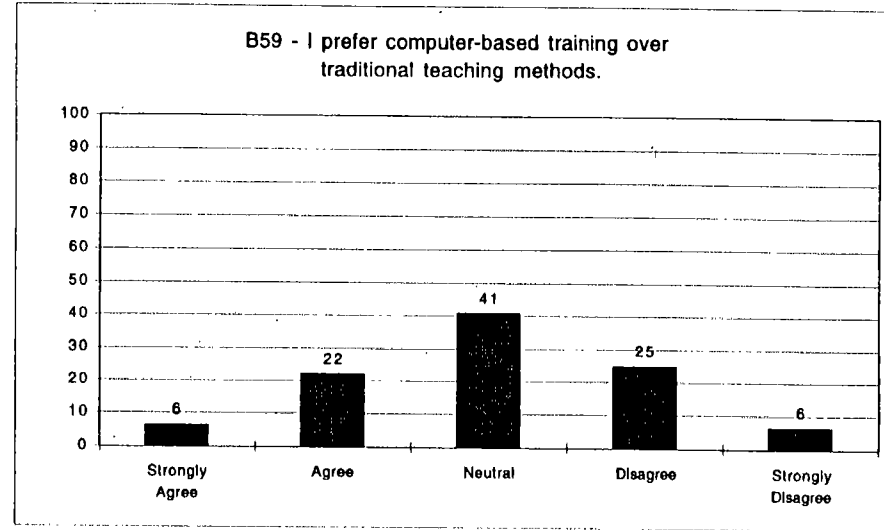
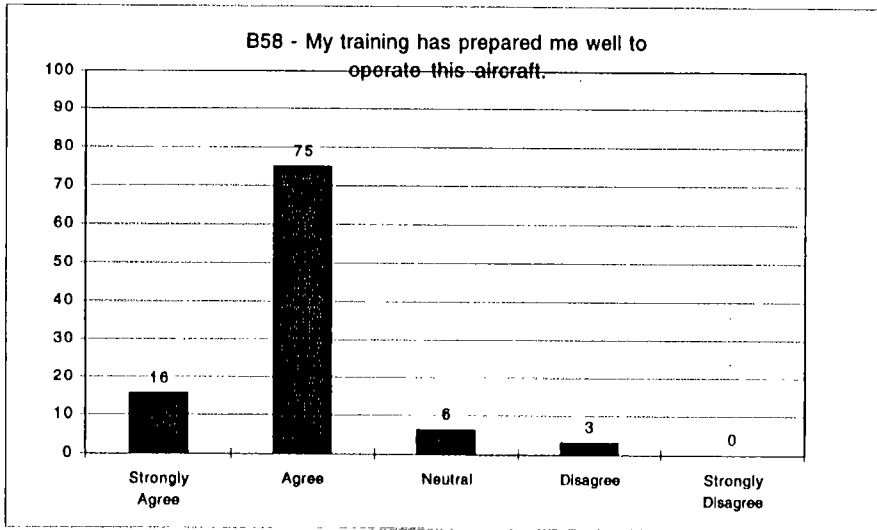


B56 - I sometimes have difficulty understanding information in the technical manuals associated with this aircraft.

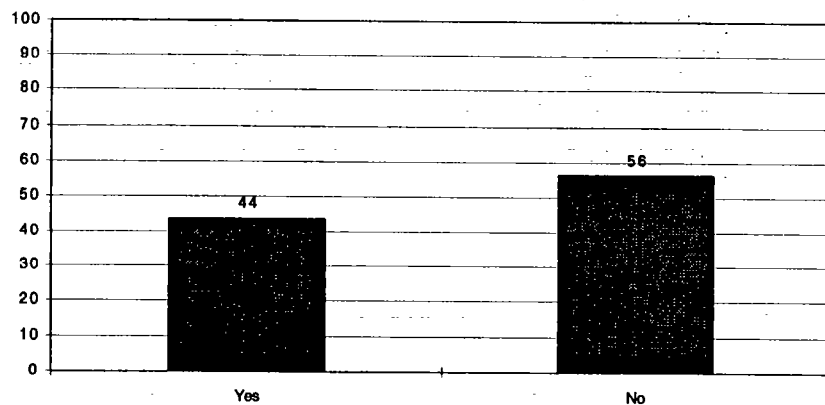


B57 - I was able to find all the information I needed for my training in the aircraft/company technical manuals.





B63 - Did you discuss any advanced technology aircraft accidents or incidents during your training?



Appendix 4 Statistical evaluation - the correlation of closed questions in part A and part B

	A4	A11	A14	A15	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B14	B15	B16
A4	1.00																
A11	0.46	1.00															
A14	0.83	0.37	1.00														
A15	0.03	0.33	0.05	1.00													
B1	0.01	-0.24	-0.08	-0.21	1.00												
B2	0.13	-0.11	-0.03	-0.33	0.26	1.00											
B3	-0.23	-0.35	-0.32	-0.26	0.36	0.40	1.00										
B4	-0.18	-0.08	-0.40	0.08	0.07	-0.07	0.11	1.00									
B5	-0.01	0.00	0.08	0.06	-0.07	-0.38	-0.15	0.02	1.00								
B6	0.31	0.21	0.15	0.08	-0.17	-0.14	-0.49	0.06	0.56	1.00							
B7	-0.05	0.02	-0.06	0.03	0.10	-0.10	-0.19	0.06	0.63	0.46	1.00						
B8	-0.02	-0.16	-0.09	-0.17	0.35	0.44	0.35	0.02	-0.08	-0.11	-0.24	1.00					
B9	0.20	0.30	0.30	0.37	-0.25	-0.21	-0.32	-0.26	0.20	0.18	-0.12	0.00	1.00				
B10	-0.08	-0.03	-0.09	0.20	-0.20	0.06	0.01	0.34	-0.11	0.21	-0.02	0.11	0.05	1.00			
B14	0.18	0.34	0.07	0.05	-0.23	0.21	-0.05	-0.13	-0.01	0.23	-0.12	0.22	0.12	0.26	1.00		
B15	-0.11	0.25	-0.18	0.20	0.06	0.01	-0.14	0.16	-0.27	-0.04	-0.23	0.31	0.00	0.25	0.49	1.00	
B16	0.20	0.10	0.12	-0.04	0.16	-0.18	0.01	0.03	-0.01	-0.04	0.05	-0.14	-0.12	-0.28	0.01	-0.18	1.00
B17	0.18	0.47	0.24	0.16	-0.47	-0.29	-0.53	-0.20	0.19	0.18	0.31	-0.39	0.16	-0.12	0.30	-0.06	0.24
B18	0.27	0.44	0.13	0.07	-0.38	-0.04	-0.51	0.04	0.23	0.47	0.29	-0.42	0.12	-0.04	0.15	0.05	0.06
B19	0.08	0.38	0.16	0.10	-0.32	-0.37	-0.50	-0.12	0.49	0.41	0.43	-0.44	0.16	-0.13	-0.04	-0.28	0.04
B22	-0.04	-0.14	0.03	-0.22	0.39	0.26	0.32	-0.21	-0.42	-0.29	-0.47	0.47	-0.04	0.10	-0.11	0.10	-0.07
B23	0.09	0.17	0.13	0.43	-0.13	-0.26	-0.29	-0.27	0.33	0.15	0.42	-0.54	0.33	-0.36	-0.35	-0.36	0.05
B24	0.20	0.54	0.21	0.25	-0.25	-0.24	-0.46	-0.09	0.19	0.50	0.37	-0.52	0.00	0.01	0.16	0.12	-0.04
B25	0.38	0.24	0.41	0.19	-0.12	-0.16	-0.60	-0.24	0.62	0.66	0.48	-0.12	0.36	-0.09	0.09	-0.16	-0.11
B26	0.30	0.41	0.40	0.17	-0.47	-0.31	-0.63	-0.05	0.48	0.46	0.18	-0.25	0.45	-0.07	0.14	-0.22	0.00
B27	0.42	0.42	0.33	-0.01	-0.34	-0.20	-0.40	-0.03	0.30	0.54	0.22	-0.34	0.33	0.04	0.19	-0.19	0.03
B28	-0.01	-0.08	-0.01	0.08	0.21	0.20	0.36	-0.17	-0.34	-0.46	-0.35	0.35	-0.18	-0.10	0.17	0.24	0.02
B29	-0.21	0.08	-0.25	0.34	-0.27	0.06	0.11	-0.05	0.03	0.11	0.04	-0.17	0.08	0.27	0.17	-0.16	-0.06
B31	-0.09	-0.42	-0.07	0.02	0.11	0.06	0.27	0.18	0.01	-0.04	-0.02	-0.08	-0.18	0.04	-0.48	-0.45	0.28
B32	-0.11	-0.22	-0.09	-0.13	-0.01	0.44	0.36	-0.25	-0.24	-0.21	-0.22	0.21	-0.11	0.03	0.05	-0.29	0.13
B33	0.16	-0.16	0.22	-0.23	0.20	0.48	-0.07	-0.13	-0.37	-0.06	-0.17	0.29	-0.12	0.18	0.21	0.09	0.14

	B17	B18	B19	B22	B23	B24	B25	B26	B27	B28	B29	B31	B32	B33
A4														
A11														
A14														
A15														
B1														
B2														
B3														
B4														
B5														
B6														
B7														
B8														
B9														
B10														
B14														
B15														
B16														
B17	1.00													
B18	0.55	1.00												
B19	0.39	0.43	1.00											
B22	-0.59	-0.48	-0.23	1.00										
B23	0.30	0.36	0.37	-0.37	1.00									
B24	0.31	0.45	0.50	-0.19	0.35	1.00								
B25	0.41	0.50	0.52	-0.35	0.42	0.33	1.00							
B26	0.59	0.50	0.52	-0.45	0.29	0.35	0.67	1.00						
B27	0.50	0.44	0.38	-0.45	0.15	0.39	0.47	0.71	1.00					
B28	-0.25	-0.29	-0.42	0.27	-0.16	-0.22	-0.22	-0.21	-0.31	1.00				
B29	-0.06	0.06	0.27	0.07	0.29	0.29	0.08	0.06	-0.01	0.19	1.00			
B31	-0.43	-0.15	-0.02	0.22	0.17	-0.26	-0.11	-0.25	-0.28	0.02	0.30	1.00		
B32	-0.30	-0.25	-0.24	0.27	0.04	-0.23	-0.21	-0.22	-0.34	0.47	0.49	0.46	1.00	
B33	-0.09	-0.32	-0.39	0.26	-0.31	-0.16	-0.04	-0.10	-0.07	0.19	-0.09	0.10	0.40	1.00

	A4	A11	A14	A15	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B14	B15	B16
B34	0.26	0.38	0.34	0.38	0.00	-0.07	-0.44	-0.27	0.16	0.25	0.37	-0.21	0.07	-0.06	-0.01	-0.02	0.20
B36	-0.08	-0.22	-0.07	-0.27	0.47	0.27	0.14	-0.19	-0.08	-0.01	0.19	0.05	-0.31	0.01	-0.08	0.13	-0.07
B37	-0.21	-0.04	-0.10	0.13	0.05	-0.21	0.09	0.03	0.37	0.09	0.43	-0.17	-0.03	0.21	-0.09	-0.15	-0.10
B38	0.03	0.22	0.17	0.07	-0.05	-0.23	-0.19	-0.14	0.47	0.32	0.49	-0.34	0.40	0.10	-0.08	-0.16	0.00
B41	-0.01	-0.08	0.11	0.12	0.05	0.14	0.06	-0.28	0.06	-0.10	0.08	0.13	-0.03	-0.13	-0.08	-0.37	0.10
B42	-0.17	-0.26	-0.07	-0.12	0.30	0.33	0.38	-0.04	-0.39	-0.35	-0.16	0.38	-0.29	0.32	0.03	0.29	-0.15
B43	-0.20	0.09	-0.29	-0.01	0.14	0.06	0.42	0.15	0.03	-0.02	0.00	0.37	-0.11	0.20	0.23	0.31	-0.10
B44	0.01	-0.07	0.16	-0.18	0.00	0.00	-0.30	-0.28	0.34	0.11	0.19	-0.02	0.35	-0.25	-0.09	-0.26	-0.15
B46	-0.22	-0.37	-0.21	-0.17	0.46	0.04	0.36	0.22	-0.07	-0.24	0.11	0.07	-0.55	-0.06	-0.24	-0.10	0.24
B47	-0.04	0.24	0.21	0.09	-0.22	-0.25	-0.40	-0.02	0.28	0.24	0.41	-0.16	0.03	0.08	0.07	0.05	0.02
B48	0.12	0.30	0.21	0.27	-0.13	-0.29	-0.43	-0.20	0.16	0.20	0.30	-0.57	0.44	-0.07	-0.15	-0.21	-0.06
B53	0.31	-0.02	0.08	-0.16	0.39	0.33	0.27	0.12	-0.35	-0.10	-0.42	0.36	-0.07	-0.12	0.03	0.21	0.22
B54	0.00	0.36	-0.02	0.30	-0.29	-0.30	-0.26	-0.16	0.35	0.32	0.38	-0.18	0.15	0.14	0.31	-0.05	0.16
B55	0.01	-0.04	0.04	0.11	-0.15	-0.21	-0.18	0.31	0.39	0.26	0.34	-0.16	-0.10	0.11	-0.08	0.00	-0.38
B56	0.22	0.10	0.32	0.37	-0.39	-0.37	-0.49	-0.06	0.51	0.44	0.59	-0.39	0.16	0.01	-0.12	-0.30	-0.04
B57	-0.24	-0.18	-0.35	-0.18	0.21	0.30	0.43	0.05	-0.48	-0.42	-0.32	0.12	-0.30	-0.01	0.06	0.22	0.07
B58	-0.19	-0.51	-0.29	0.02	0.50	0.37	0.43	0.22	-0.28	-0.20	0.00	0.19	-0.23	0.06	-0.31	-0.04	0.04
B59	-0.11	-0.37	-0.23	-0.28	0.48	0.06	0.27	0.26	0.20	0.15	0.22	0.28	-0.07	-0.01	-0.28	-0.11	0.03

	B17	B18	B19	B22	B23	B24	B25	B26	B27	B28	B29	B31	B32	B33	B34	B36	B37
B34	0.33	0.25	0.39	-0.09	0.49	0.46	0.51	0.35	0.29	0.01	0.29	0.14	0.02	0.26	1.00		
B36	-0.26	0.00	-0.22	0.38	0.02	0.10	0.01	-0.37	-0.40	0.18	0.00	0.02	0.10	0.17	-0.01	1.00	
B37	0.21	0.10	0.26	-0.18	0.13	-0.01	0.16	0.00	0.03	-0.24	-0.06	0.08	-0.27	-0.42	0.06	0.02	1.00
B38	0.25	0.42	0.44	-0.14	0.40	0.25	0.53	0.28	0.28	-0.37	0.12	0.08	-0.16	-0.27	0.31	0.12	0.54
B41	-0.02	-0.32	-0.05	-0.04	0.20	-0.16	0.17	0.05	-0.20	0.30	0.29	0.15	0.61	0.40	0.25	0.01	-0.27
B42	-0.36	-0.57	-0.38	0.44	-0.54	-0.26	-0.39	-0.47	-0.21	0.26	-0.08	0.04	-0.04	0.42	0.07	0.17	0.07
B43	-0.14	-0.19	-0.32	0.17	-0.27	-0.05	-0.22	-0.16	-0.03	0.15	-0.01	-0.24	-0.10	-0.18	-0.11	0.16	0.33
B44	0.16	0.22	0.32	-0.11	0.35	-0.01	0.47	0.37	0.08	0.02	0.09	-0.07	0.19	0.06	0.11	-0.01	-0.19
B46	-0.23	-0.33	-0.07	0.34	-0.13	-0.17	-0.35	-0.47	-0.52	0.10	-0.08	0.32	0.00	0.04	-0.10	0.39	0.20
B47	0.54	0.36	0.37	-0.21	0.17	0.40	0.39	0.43	0.25	-0.22	0.13	-0.15	-0.25	-0.08	0.44	-0.02	0.24
B48	0.48	0.38	0.32	-0.34	0.72	0.33	0.37	0.39	0.42	-0.36	0.14	-0.10	-0.20	-0.19	0.36	0.01	0.16
B53	-0.41	-0.15	-0.64	0.32	-0.24	-0.27	-0.19	-0.24	-0.10	0.44	-0.17	0.20	0.24	0.38	-0.10	0.30	-0.44
B54	0.53	0.21	0.25	-0.35	0.25	0.38	0.33	0.38	0.33	-0.21	0.29	-0.23	-0.07	-0.10	0.39	-0.12	0.26
B55	-0.03	0.18	0.36	-0.29	0.07	0.21	0.31	0.24	0.23	-0.03	0.03	0.00	-0.28	-0.28	0.15	-0.20	0.27
B56	0.42	0.37	0.53	-0.53	0.58	0.38	0.61	0.51	0.34	-0.16	0.18	0.11	-0.08	-0.19	0.50	-0.26	0.26
B57	-0.30	-0.15	-0.36	0.34	-0.21	-0.32	-0.54	-0.53	-0.33	0.49	0.10	0.20	0.31	0.09	-0.24	0.39	-0.13
B58	-0.63	-0.30	-0.54	0.28	-0.07	-0.28	-0.27	-0.57	-0.55	0.31	0.09	0.47	0.38	0.18	-0.23	0.48	-0.10
B59	-0.44	-0.33	-0.27	0.08	-0.19	-0.26	-0.06	-0.13	0.15	-0.08	-0.28	0.06	-0.10	0.12	-0.13	0.10	-0.14

	B38	B41	B42	B43	B44	B46	B47	B48	B53	B54	B55	B56	B57	B58	B59
B34															
B36															
B37															
B38	1.00														
B41	-0.12	1.00													
B42	-0.25	-0.03	1.00												
B43	0.07	-0.21	0.32	1.00											
B44	0.24	0.36	-0.41	-0.54	1.00										
B46	-0.19	0.03	0.28	0.09	-0.14	1.00									
B47	0.44	-0.01	-0.03	0.06	0.21	0.01	1.00								
B48	0.46	-0.04	-0.40	-0.22	0.30	-0.23	0.37	1.00							
B53	-0.30	-0.02	0.14	0.18	-0.26	-0.05	-0.45	-0.26	1.00						
B54	0.26	0.04	-0.20	0.23	-0.14	-0.39	0.27	0.28	-0.22	1.00					
B55	0.19	-0.08	-0.04	-0.01	0.16	0.04	0.24	-0.06	-0.36	-0.20	1.00				
B56	0.38	0.21	-0.37	-0.27	0.34	-0.11	0.47	0.38	-0.50	0.24	0.59	1.00			
B57	-0.29	-0.09	0.27	0.13	-0.20	0.39	-0.37	-0.18	0.41	-0.47	-0.10	-0.45	1.00		
B58	-0.09	0.15	0.17	0.04	-0.19	0.27	-0.36	-0.28	0.47	-0.31	-0.17	-0.25	0.34	1.00	
B59	0.00	0.03	0.21	0.26	-0.05	0.06	-0.24	-0.16	0.27	-0.17	0.10	-0.17	0.03	0.33	1.00