5. AIRLINE INDUSTRY SURVEY OF HAZARDS ASSOCIATED WITH RELIANCE ON FLIGHT DECK AUTOMATION

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5. AIRLINE INDUSTRY SURVEY OF HAZARDS ASSOCIATED WITH RELIANCE ON FLIGHT DECK AUTOMATION

5.1 Scope of Survey

The objective of this questionnaire was to determine the opinion by senior members from the airline sector to the JAA industry based research project "Future Hazards Associated with Flight Deck Automation". This particular questionnaire was seen as an integral part of the validation process of the work performed by the ad-hoc expert panel which was convened for this area of research. The target response group for this questionnaire was the more experienced and senior members of the various airline operations and regulatory departments. More specifically this survey was aimed at those involved in pilot training and testing at different levels. Statistical data has been generated as a result of the answers given and is presented in this report.

This study contains demographic data and three main sub-areas of examination with respect to reliance on flight deck automation. These three sub-areas are as follows:

1. Relevance of and Establishment of Level of Manual Flying Skills Associated with Current Levels of Flight Deck Automation.
2. Training Requirements as a Result of Advances Made in Flight Deck Automation.
3. Safety, Human Factors & Operational Procedures.

The questionnaire was completed both electronically and conventionally by a total of sixty five (65) organisations throughout both continental Europe and the United Kingdom. It was purely voluntary with no remuneration or reward for any of the participants. From the demographic breakdown it can be seen that there was randomness in the nationality of the people who participated however, all most all of the respondents were male and the majority were in the age groups 45-50 years and 50+ years. The survey was conducted over an eight (8) week period. One hundred and ninety nine questionnaires were completed satisfactorily. Six (6) questionnaires were void because of incompleteness or other errors.

5.2 Demographics

As previously stated the target audience for this questionnaire was the senior and more experienced members of airline and regulatory authority flight operations departments. Table 5.1 shows the statistical breakdown per time in airline industry, total flying experience and age group of the respondents. Table 5.3 shows a breakdown of the organisations which participated in this exercise. Table 5.4 shows a breakdown of respondents by positions held in respective organisations.

Table 5.5 shows time spent in the airline industry (in years) by the respondents to this questionnaire. Table 5.6 shows the locations of the respondents. Table 5.7 shows the respective aircraft types flown by the respondents. Figure 5.1 shows the respective age group(s) of the respondents and figure 5.2 shows the total flying experience of the participants. With very few exceptions it can be said clearly that the target audience for this survey was reached.

	time in airline industry (years)	total flying experience (hours)	age group (1 to 7)
Mean	20.4	10216.0	5.30
Median	20.00	10000.00	6.00
Mode	30	10000	6
Std. Deviation	10.356	4521.65	1.56
Range	49	21600	6
Minimum	1	400	1
Maximum	50	22000	7

Table 5.1 Statistical Breakdown of Respondents

5.2.1 Scale of Responses

A Likert scale was used in this questionnaire in order to ascertain opinions from the target audience on thirty two (32) separate questions which were divided into three (3) main sections. The scale started at -4 which equated to extreme disagreement with the statement or suggestion on the survey form up to +4 which indicated extreme agreement with the statement. Table 5.2 shows the scale.

Option	Verbal Comparison
+4	Extreme Agreement
+3	Very Strong Agreement
+2	Strong Agreement
+1	Moderate Agreement
0	Neutral
-1	Moderate Disagreement
-2	Strong Disagreement
-3	Very Strong Disagreement
-4	Extreme Disagreement

Table 5.2 Likert Scale for Questionnaire Responses

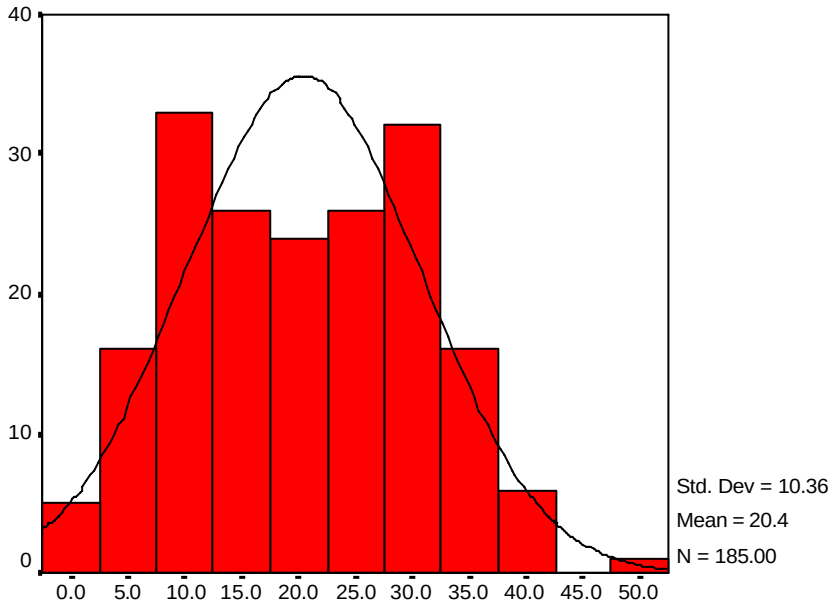

Figure 5.1 Time Spent in Airline Industry by Respondents (Years)

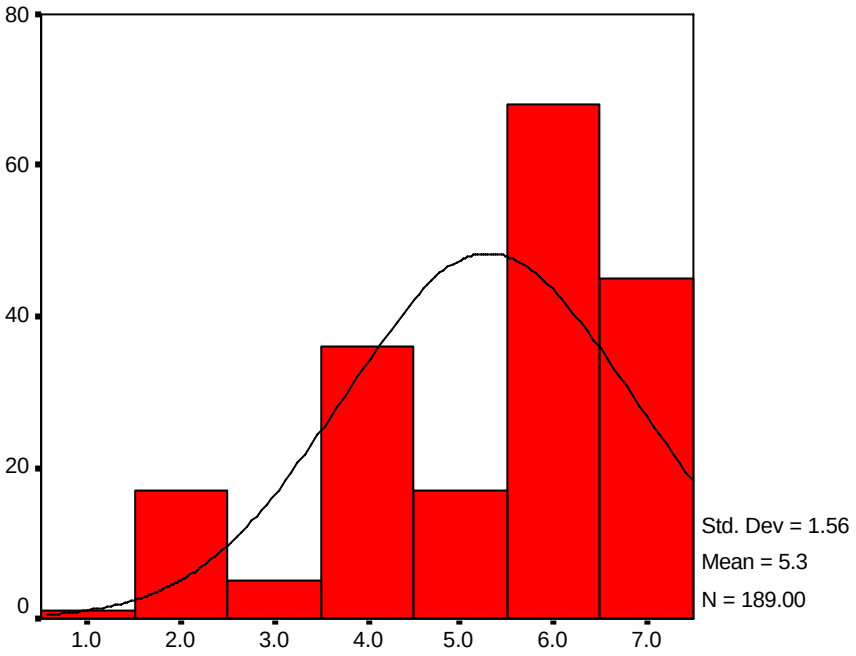

Figure 5.2 Respective Age Group(s) of Respondents

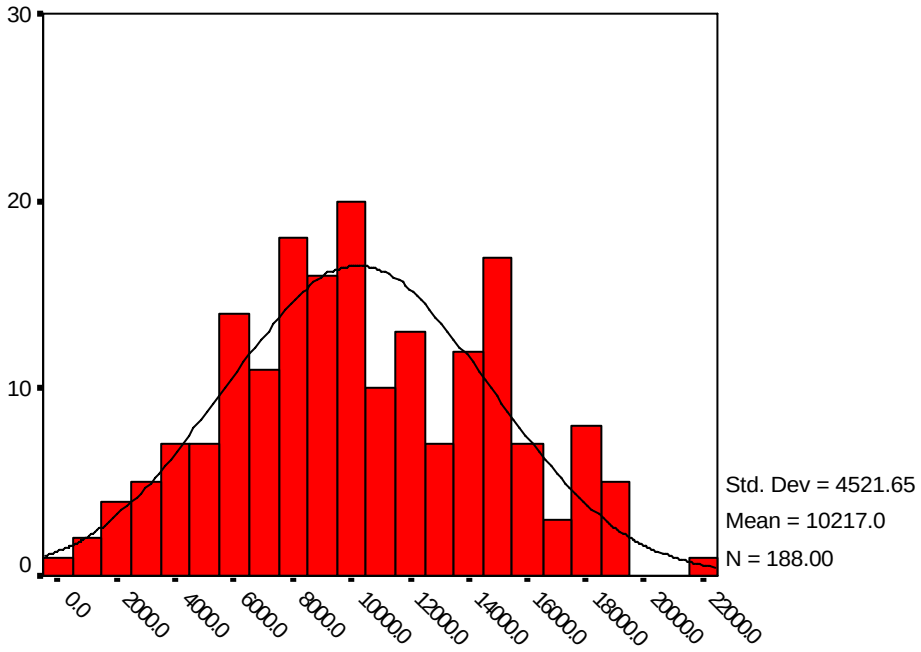

Figure 5.3 Total Flying Experience (in hours) of Respondents

Adria Airways	IVW/DHL/KLM
Aerocondor	Jet Aviation
Air Alps	JNAC
Air Botnia	KLM
Air Luxor	KLM Cityhopper
Air Slovakia	KLM Exel
Air Styria	Krono Air
Airlink	LPR/GILC/LOT
Alitalia	Lufthansa
Artemis	Lufthansa Cityline
Austrian Airlines	MAT-Macedonian Airlines
Automobilivetr AG	Netjets
Avioimpex	Northern Executive Aviation
Azzura-Air	Philips Aviation
BMI Regional	Portugalia
Bosch	Rabbit Air
CAA Netherlands	Régional
CAA Slovakia	Shell Aircraft
CAT Aviation	Sky Europe Airlines
DCA	Swiss International Airlines
DCA Malta	Swisswings
Deutche BA	TAP Air Portugal
ENAC	Tyrolean Air Services
Eurolot	UK CAA
Finnair	VIP Avia
Flight Safety Authority Finland	Volkswagen
FOCA	WEA
Ford	Welcome Air
Gandalf	Yes
IBM	Lauda Air
INAC	

Table 5.3 List of Participating Organisations

Position	Frequency	Percent
Assistant Fleet Chief	2	1.0
Captain	56	29.0
Check Captain	2	1.0
Chief Inspector	1	.5
Chief Pilot	16	8.3
Chief Training Captain	1	.5
Department Chief	1	.5
Director	3	1.6
Director of Flight Operations	8	4.1
First Officer	10	5.2
Fleet Chief	1	.5
Flight Operations Inspector	24	12.4
Flight Operations Manager	1	.5
Flight Safety Inspector	2	1.0
Head of Training	2	1.0
Manager	1	.5
Operations Manager	1	.5
President	1	.5
Regional Manager	1	.5
Safety & Quality Manager	1	.5
Safety Officer	2	1.0
Senior Captain	1	.5
Senior Instructor	1	.5
Technical Pilot	1	.5
Training Captain	13	6.7
Training Manager	3	1.6
Type Rating Examiner	10	5.2
Type Rating Instructor	23	11.9
VP Flight Operations	1	.5
VP Flight Safety	1	.5
Total	193	100.0

Table 5.4 Breakdown of Respondents by Position Held In Respective Organisations

Years in Airline Industry	Frequency	Percent
1	1	.5
2	4	2.1
3	2	1.0
4	4	2.1
5	6	3.1
6	1	.5
7	3	1.6
8	5	2.6
9	2	1.0
10	11	5.7
11	5	2.6
12	10	5.2
13	4	2.1
14	4	2.1
15	7	3.6
16	7	3.6
17	4	2.1
18	3	1.6
19	2	1.0
20	8	4.1
21	1	.5
22	10	5.2
23	3	1.6
24	3	1.6
25	13	6.7
26	2	1.0
27	5	2.6
28	6	3.1
29	3	1.6
30	15	7.8
31	3	1.6
32	5	2.6
33	1	.5
34	6	3.1
35	7	3.6
36	1	.5
37	1	.5
38	2	1.0
40	3	1.6
42	1	.5
50	1	.5
Sub-Total	185	95.9
no answer given	8	4.1
Total	193	100.0

Table 5.5 Breakdown of Time Spent In Airline Industry by Respondents

Location	Frequency	Percent
Aberdeen	3	1.6
Amsterdam	4	2.1
Bergamo	8	4.1
Berlin	5	2.6
Berne	1	.5
Bratislava	3	1.6
Cascais	4	2.1
Cologne	1	.5
East Midlands	1	.5
Eindhoven	1	.5
Frankfurt	2	1.0
Gatwick	2	1.0
Graz	1	.5
Hamburg	4	2.1
Hannover	1	.5
Helsinki	14	7.3
Hoofddorp	5	2.6
Innsbruck	3	1.6
Lisbon	24	12.4
Lubljana	11	5.7
Maastricht	1	.5
Malta	1	.5
Manchester	3	1.6
Milano	1	.5
Munich	5	2.6
Nantes	1	.5
Orio	1	.5
Oslo	4	2.1
Paris	2	1.0
Riga	1	.5
Rome	8	4.1
Rotterdam	1	.5
Salzburg	3	1.6
Schipol	1	.5
Skopje	8	4.1
Slovakia	2	1.0
Stansted	8	4.1
Stuttgart	2	1.0
Vienna	11	5.7
Warsaw	22	11.4
Zürich	6	3.1
Total	193	100.0

Table 5.6 Breakdown of Respondents by Location

Aircraft Type	Frequency	Percent
Airbus A310	1	.5
Airbus A319 Falcon 900	1	.5
Airbus A319 / L360	1	.5
Airbus A319/320/321	20	10.4
Airbus A320 MD-80	1	.5
Airbus A320 / A330	1	.5
Airbus A330/340	4	2.1
ATR 42/72	4	2.1
Avro RJ	2	1.0
Bae 146	4	2.1
Boeing 757/767	6	3.1
Boeing 737	20	10.4
Boeing 737 L-410	1	.5
Boeing 737 / 767	1	.5
Boeing 747-400	1	.5
Boeing 747 MD-80	1	.5
Boeing 757/767	3	1.6
Canadair RJ	15	7.8
Cessna 550/560	4	2.1
Cessna 750	1	.5
DC-8-72	1	.5
DHC-8 Cessna 560	1	.5
Dornier 228 Shorts 360	3	1.6
Dornier 328	12	6.2
Dornier 328 Cessna 500	1	.5
Dornier 328 Cessna 550 / 560	1	.5
Embraer 120	2	1.0
Embraer 145	8	4.1
Falcon 900 Challenger 604	1	.5
Falcon 900/2000	6	3.1
Falcon 900B Lear 35A	1	.5
Fokker 50	1	.5
Fokker 70/100	17	8.8
Fokker 70/100 MD-80	1	.5
G-4 /DA50	1	.5
Gulfstream IV	1	.5
HS 125	2	1.0
L-1011	3	1.6
L-410	4	2.1
L-410 IL-18	1	.5
MD-11	7	3.6
MD-80	10	5.2
MD-80 ATR 72 Airbus A320	1	.5
SAAB 2000	2	1.0
Tupelov 154M	1	.5
YK-40	1	.5
Total	193	100.0

Table 5.7 Breakdown of Respondents by Current Aircraft Type Flown

5.3 Section One of Questionnaire – Relevance of Manual Flying Skills

5.3.1 Question 1A – Manual flying skills have deteriorated through the advent of autoflight

Mean Value	1.3
Median Value	2.0
Mode	2.0
Standard Deviation	2.07
Range	8.0
Minimum	-4.0
Maximum	4.0

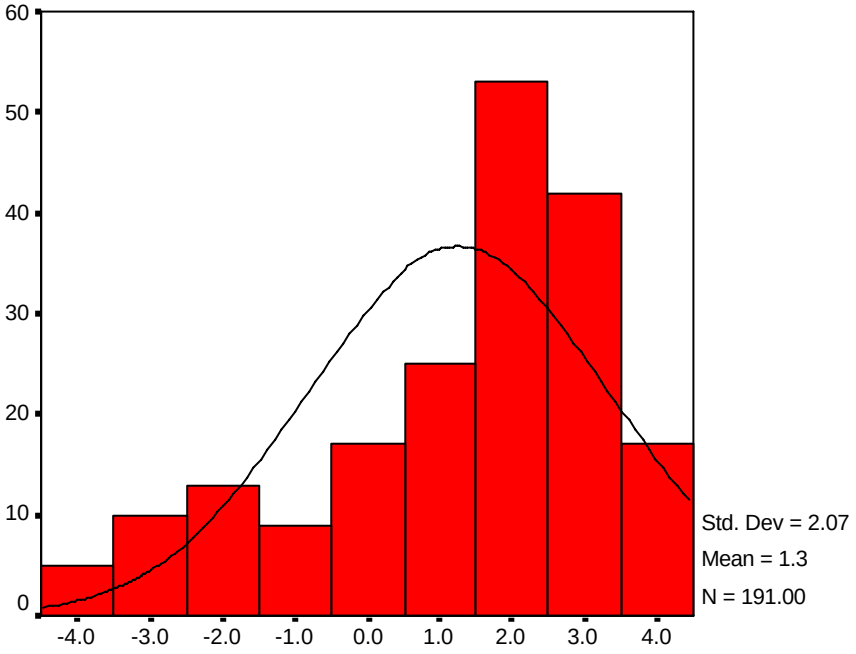

Figure 5.4 Question 1A Histogram & Normal Distribution

Question 1A gave a median response of 2.0 which equated to strong agreement with the statement that manual flying skills have deteriorated through the advent of autoflight.

5.3.2 Question 1B – Manual flying skills have deteriorated through advances made in flight deck automation

Mean Value	1.0
Median Value	2.0
Mode	2.0
Standard Deviation	2.15
Range	8.0
Minimum	-4.0
Maximum	4.0

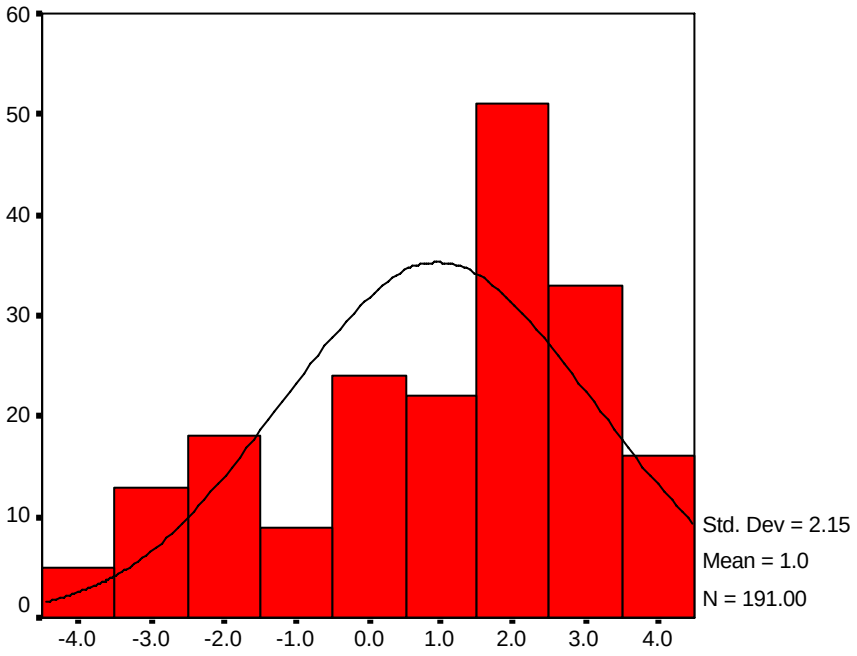

Figure 5.5 Question 1B Histogram & Normal Distribution

Question 1B gave a median value of 2.0 which equated to strong agreement that manual flying skills have deteriorated through advances made in flight deck automation.

5.3.3 Question 1C – Manual flying skills are considered secondary to system management since the advent of autoflight

Mean Value	-0.10
Median Value	0.0
Mode	2.0
Standard Deviation	2.53
Range	8.0
Minimum	-4.0
Maximum	4.0

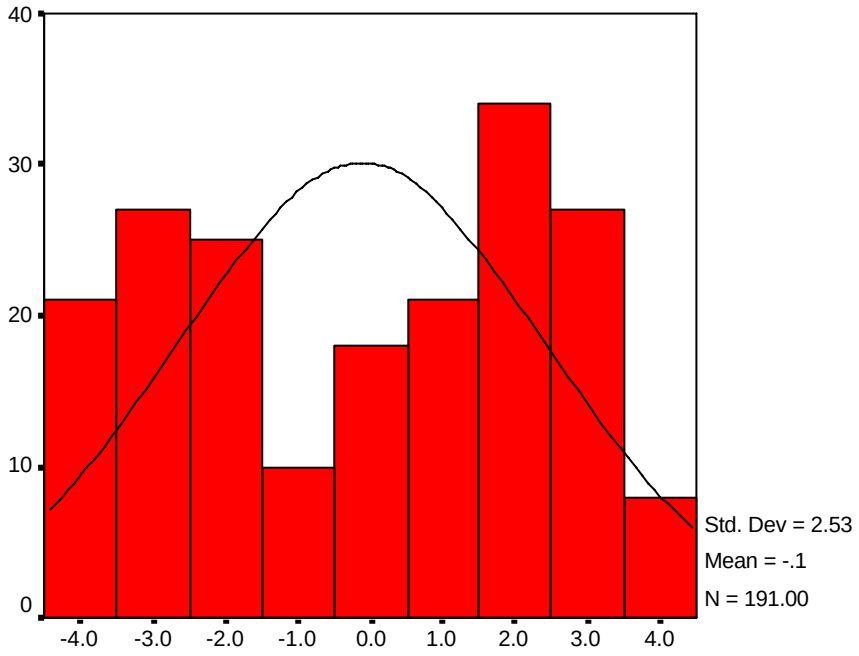

Figure 5.6 Question 1C Histogram & Normal Distribution

Question 1C gave a median value of 0.0 which equated to no overriding opinion either way that manual flying skills are considered secondary to system management since the advent of autoflight.

5.3.4 Question 1D – Manual flying skills are considered secondary to system management through advances made in flight deck automation

Mean Value	-0.20
Median Value	0.0
Mode	3.0
Standard Deviation	2.56
Range	8.0
Minimum	-4.0
Maximum	4.0

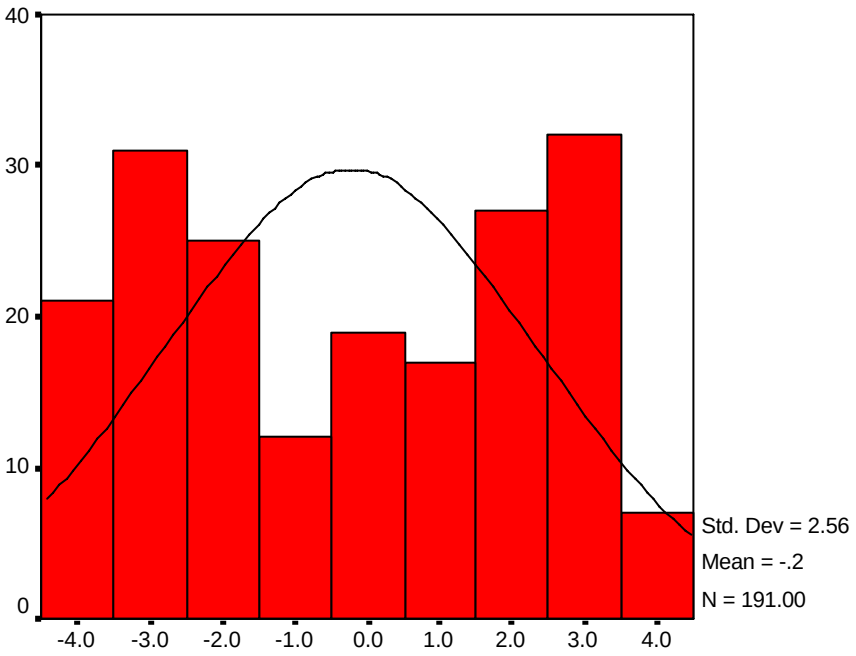

Figure 5.7 Question 1D Histogram & Normal Distribution

Question 1D gave a median value of 0.0 which equated to no overriding opinion either way that manual flying skills are considered secondary to system management through advances made in flight deck automation.

5.3.5 Question 1E – Future levels of flight deck automation will result in a decreased level of required manual flying skills

Mean Value	0.70
Median Value	2.0
Mode	2.0
Standard Deviation	2.52
Range	8.0
Minimum	-4.0
Maximum	4.0

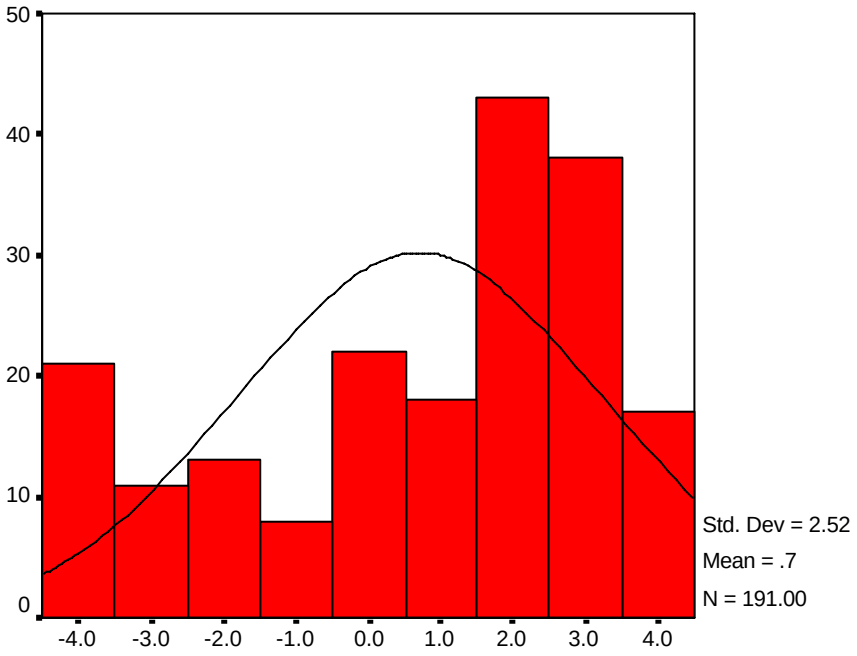

Figure 5.8 Question 1E Histogram & Normal Distribution

Question 1E gave a median value of 2.0 which equated to a strong agreement that future levels of flight deck automation will result in a decreased level of required manual flying skills.

5.3.6 Question 1F – I prefer flying aeroplanes with a high level of automation

Mean Value	1.6
Median Value	2.0
Mode	4.0
Standard Deviation	2.06
Range	8.0
Minimum	-4.0
Maximum	4.0

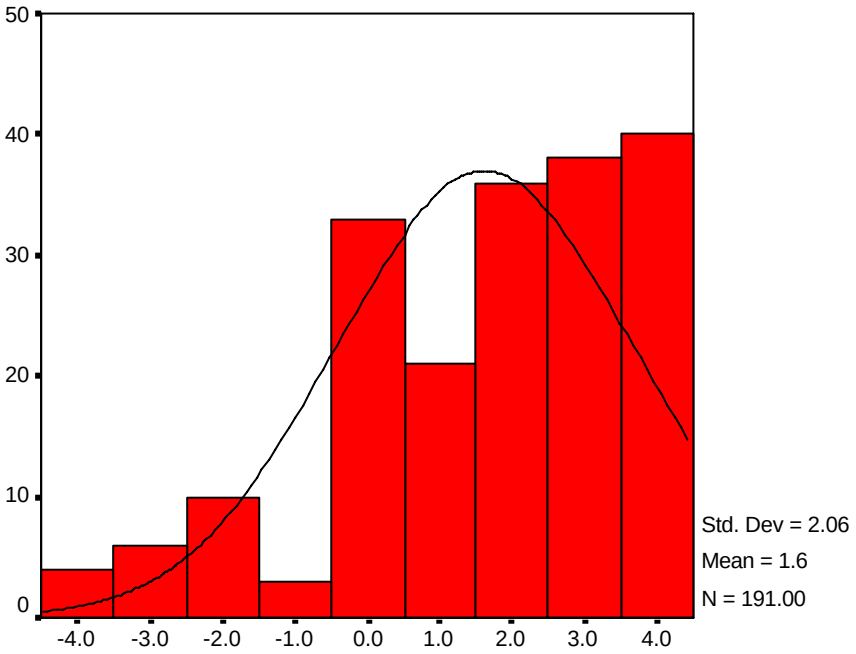

Figure 5.9 Question 1F Histogram & Normal Distribution

Question 1F gave a median value of 2.0 which equated to a strong agreement with the statement that pilots prefer flying aeroplanes with a high level of automation.

5.3.7 Question 1G – Automated cockpits demand more cross-checking between pilots

Mean Value	2.3
Median Value	3.0
Mode	4.0
Standard Deviation	1.87
Range	8.0
Minimum	-4.0
Maximum	4.0

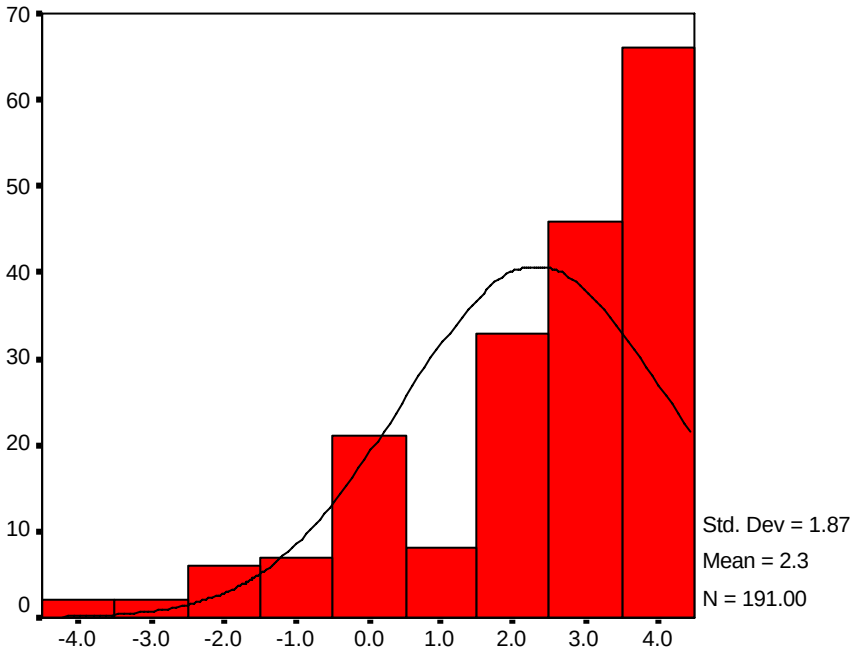

Figure 5.10 Question 1G Histogram & Normal Distribution

Question 1G gave a median value of 3.0 which equated to a very strong agreement that automated cockpits demand more cross-checking between pilots.

5.3.8 Section One Analysis – Correlation of Questionnaire Results

Section one pertained to the relationship between manual flying skills and current levels of flight deck automation.

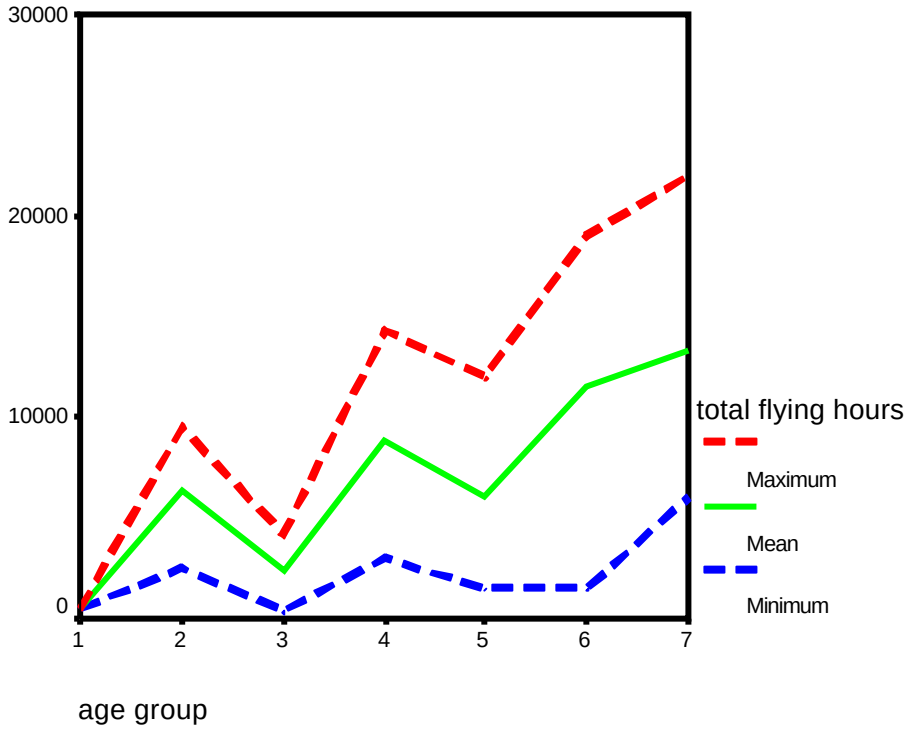

Figure 5.11 Correlations between Age Group and Total Flying Experience

As would normally be expected there is a fairly consistent relationship between the total flying experience (in hours) and the age group of the respondents. As the age group increases from 1 to 7 the trend is for the total flying experience to generally increase accordingly. The respondent with the minimum flying experience (400 hours) was situated in group 1 and the respondent with the maximum flying experience (22000 hours) was situated in group 7.

	age group						
	1	2	3	4	5	6	7
mean total flying experience (hours)	500	6321	2426	8880	6050	11511	13359

Table 5.7 Mean Total Flying Experience by Age Group

5.3.9 Correlation between Question 1A and 1B

Question 1A asked if manual flying skills had deteriorated with through the advent of autoflight and question 1B asked if the same skills had deteriorated through advances made in flight deck automation.

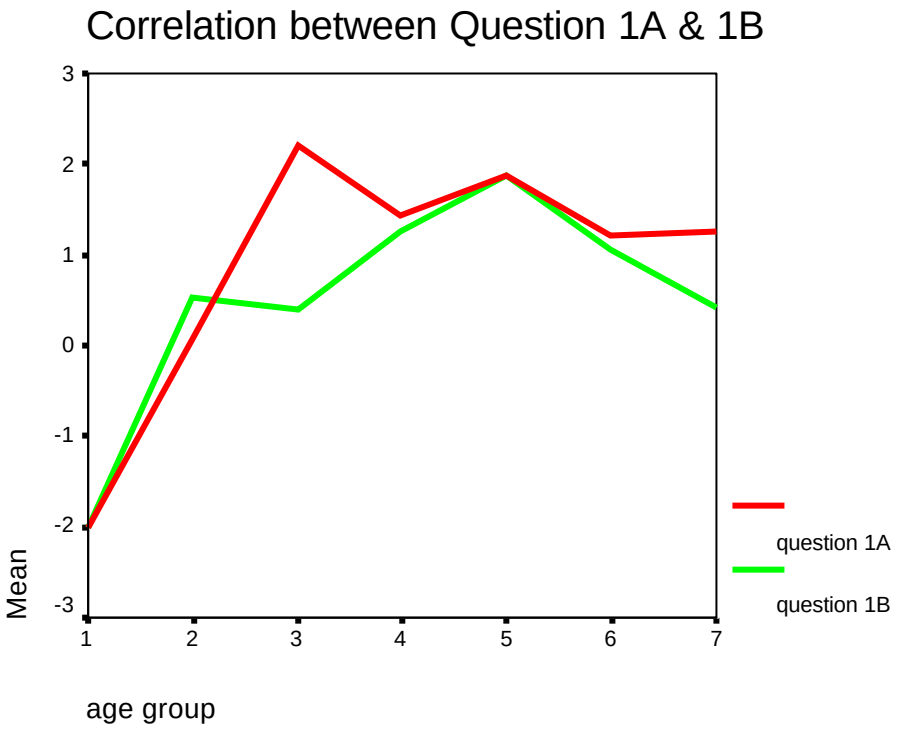

Figure 5.12 Correlations between Question 1A and 1B

Figure 5.12 shows that for both questions there was strong disagreement with the statement in age group 1 which was the 20 – 25 years old bracket. For age group 2 (25-30 years old) there was neutral to moderate agreement with both statements. In age group 3 (30-35 years old) there was only neutral to moderate agreement with the concept of manual flying skills deteriorating through advances in flight deck automation but strong agreement with the proposal that the same flying skills have suffered as a result of the advent of autoflight.

Age group 4 (35-40 years old) indicated a mainly moderate agreement with the statement in both questions. Age group 5 (40-45 years old) showed a tendency toward a strong agreement with the statement for both questions. Age groups 6 (45-50 years old) and 7 (50+ years old) both presented results which were mainly centred on moderate agreement with the statement in both questions.

From figure 5.12 it can be seen that there is a general trend towards strength of agreement with both statements as the respondent age group increases. This also corresponds with an increase in mean total flying hours with increase in age group. Thus it could be said that age group and corresponding mean total flying experience have a direct influence on the answers provided by the respondents. It could also be argued that the answers provided were based on and possibly directly influenced by the age group and the total mean flying experience of the respondents.

5.3.10 Correlation between Question 1C, 1D and 1E

Question 1C asked if manual flying skills are considered secondary to system management since the advent of autoflight and question 1D asked if the same skills were considered secondary to system management through advances made in flight deck automation. Question 1E asked if future levels of flight deck automation will result in a decreased level of required manual flying skills.

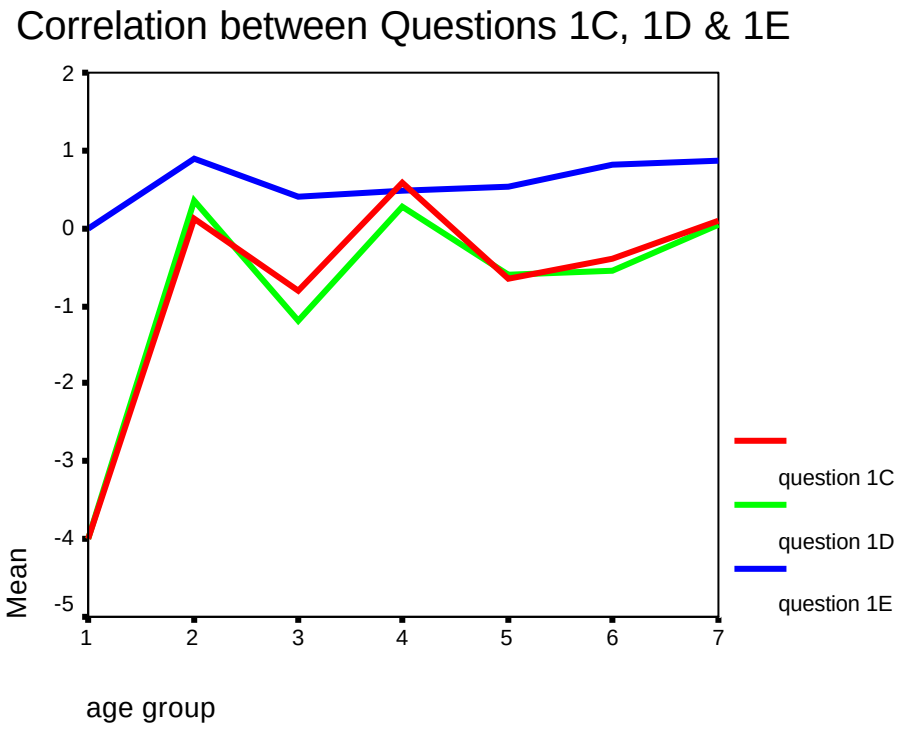

Figure 5.13 Correlations between Question 1C, 1D and 1E

Figure 5.13 shows the relationship between the results for question 1C, 1D and the results for question 1E with respect to age group. It can be seen that the responses are almost identical for questions 1C and 1D. It appears that from the responses obtained to these two questions the terms 'advanced flight deck automation' and 'autoflight' were considered synonymous. This may or may not be absolutely true but it is a fair deduction based on the results.

Like questions 1A and 1B the curves for questions 1C and 1D take the same general shape with strong disagreement with the statements occurring in the lower or younger age groups and a trend towards a higher state of agreement in the higher or older age groups. Unlike questions 1A and 1B the mean values from the responses were -0.10 and -0.20 and the median values were 0.00 (both) for questions 1C and 1D respectively. The results can be seen in figures 5.6 and 5.7. The older, more experienced respondents did not show the same strength of agreement or feeling with either statement as was previously the case in 1A and 1B. It appears that the issues concerning questions 1C and 1D may not seem that important to the older and more experienced respondents.

Question 1E displays a curve with a much smaller gradient but a trend toward agreement with increase in age group nethertheless. The mean value for responses was 0.7 and the median 2.0. There was not a lot of variation of opinion on this statement and the mean of 0.7 indicates neutral to moderate agreement and the median of 2.0 indicates moderate to strong agreement. The bulk of the answers are centred on the neutral to strong agreement bracket (0.0 to 2.0) and this can be seen in figure 5.8. It could be that there is a possibility of unsureness or indecision towards this statement by the majority of the respondents thus accounting for the low mean and median values. It may also be that the bulk of the respondents simply did not feel strongly about the statement as was the case in questions 1C and 1D.

5.3.11 Correlation between Questions 1F and 1G

Although not as directly related as the previous groups of questions in section one, questions 1F and 1G do share some common ground. Question 1F asks if the respondents prefer to fly aircraft with a high level of automation and question 1G then asks if automated cockpits demand more cross-checking between pilots.

The mean values of the responses for both questions with respect to age group are shown in figure 5.14 below. The histograms for the two questions are shown in figures 5.9 and 5.10 respectively. Before drawing to early a conclusion from figure 5.14 reference should be made to figure 5.2 where it can be seen that age groups 1 and 3 were a very small proportion of the total number of respondents and should therefore not have the same influence or be treated as significant as magnitude of the responses from the other age groups.

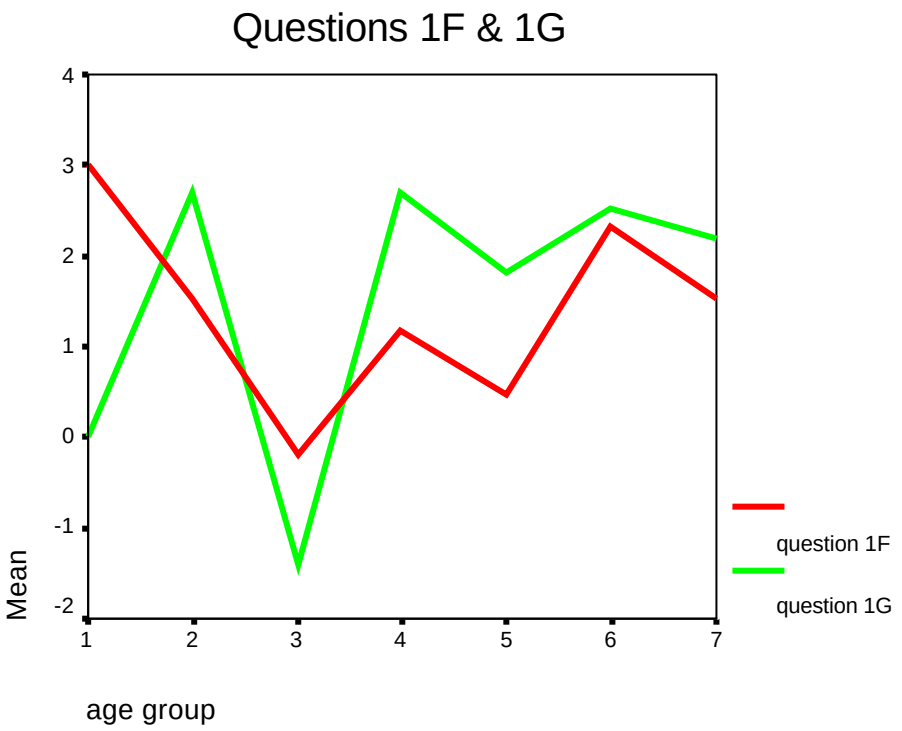

Figure 5.14 Mean Values of Respondents for Questions 1F and 1G

For question 1F the trend is deceasing from a mean value of 3.0 (very strong agreement) to approximately 1.6 (moderate to strong agreement) if the whole age group range is considered. If we considered the trend only from age group 2 up to 7 then the overall trend would be an average response of 1.6 (moderate to strong agreement). This is probably the truest mean response for this question. Figure 5.9 shows the histogram for this question. It can be said with a reasonable confidence that the majority of pilots surveyed do prefer to fly aeroplanes with a high level of automation.

Question 1G is a different matter to 1F. From figure 5.14 the trend is increasing agreement with the statement that 'automated cockpits demand more cross-checking

between pilots' with respect to increase in age group and hence experience. This is a good result in terms of the target audience for this survey because it tells us that through experience gained by the respondents (which would be consummate with having transitioned from non-automated to highly automated cockpits) there is an increasing belief that automated cockpits require more cross-checking between pilots in order to uphold control of the aircraft's behaviour and maintain situational awareness. This is a good cornerstone training philosophy to adopt with respect to potential hazards associated with future advances in flight deck automation.

5.3.12 Summary - Section One Analysis

In terms of potential hazards associated with future advances made in flight deck automation section one of the questionnaire highlights the following observations:

1. Manual flying skills have (and will more than likely continue to) deteriorated through both the advent of autoflight and advances made in flight deck automation.

2. There is no clear opinion either way that manual flying skills are (or will be) considered secondary to system management through either the advent of autoflight or advances made in flight deck automation.

3. It cannot be said with any degree of confidence that there will be a decreased level of flying skills required resulting from future levels of flight deck automation.

4. The pilots surveyed are very receptive of the idea of flying aeroplanes with a high level of automation and hopefully this can be taken as indicative of the industry as a whole.

5. It seems quite clear that the respondents as a whole agree strongly with the concept that automated cockpits demand more cross-checking between pilots. This should be a cornerstone of any training philosophy on a highly automated aircraft.

5.4 Section Two of Questionnaire – Training requirements

5.4.1 Question 2A – Advanced levels of flight deck automation have led to an increased level of training required for pilots

Mean Value	2.2
Median Value	2.0
Mode	2.0
Standard Deviation	1.66
Range	8.0
Minimum	-4.0
Maximum	4.0

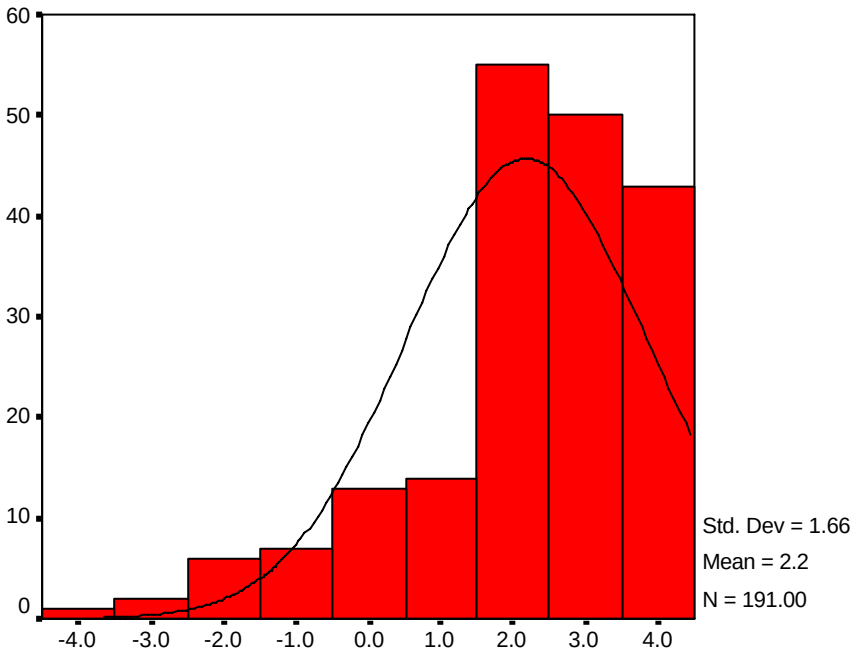

Figure 5.15 Question 2A Histogram & Normal Distribution

Question 2A gave a median value of 2.0 which equated to a strong agreement with the statement that advanced levels of flight deck automation have led to an increased level of training required for pilots.

5.4.2 Question 2B – Future levels of flight deck automation will lead to a decrease in the level of training required for pilots

Mean Value	-1.5
Median Value	-2.0
Mode	-3.0
Standard Deviation	2.36
Range	8.0
Minimum	-4.0
Maximum	4.0

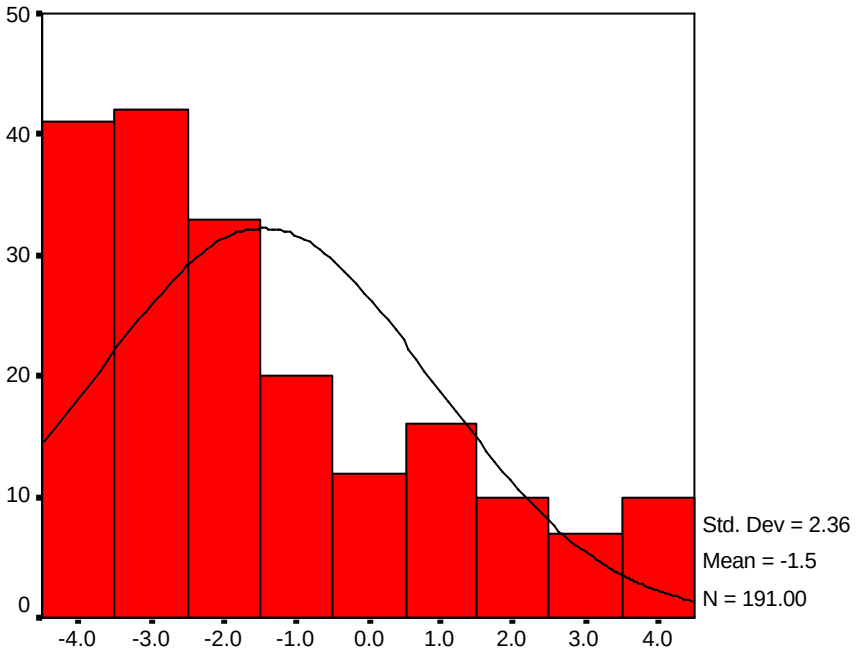

Figure 5.16 Question 2B Histogram & Normal Distribution

Question 2B gave a median value of -2.0 which equated to a strong disagreement with the statement that future levels of flight deck automation will lead to a decrease in the level of training required for pilots.

5.4.3 Question 2C – Future levels of flight deck automation will lead to a lower flying experience level for new entrant pilots

Mean Value	-0.3
Median Value	0.00
Mode	-3.0
Standard Deviation	2.64
Range	8.0
Minimum	-4.0
Maximum	4.0

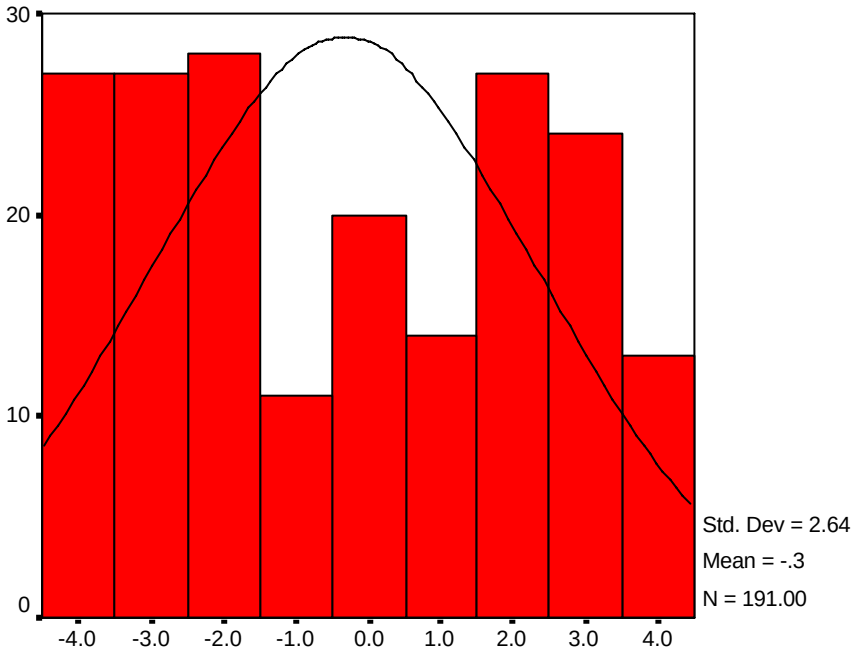

Figure 5.17 Question 2C Histogram & Normal Distribution

Question 2C gave a median value of 0.0 which to no overriding opinion either way that future levels of flight deck automation will lead to a lower flying experience level for new entrant pilots.

5.4.4 Question 2D – Future levels of flight deck automation will lead to the requirement for a better education for new entrant pilots

Mean Value	2.3
Median Value	3.0
Mode	4.0
Standard Deviation	1.78
Range	8.0
Minimum	-4.0
Maximum	4.0

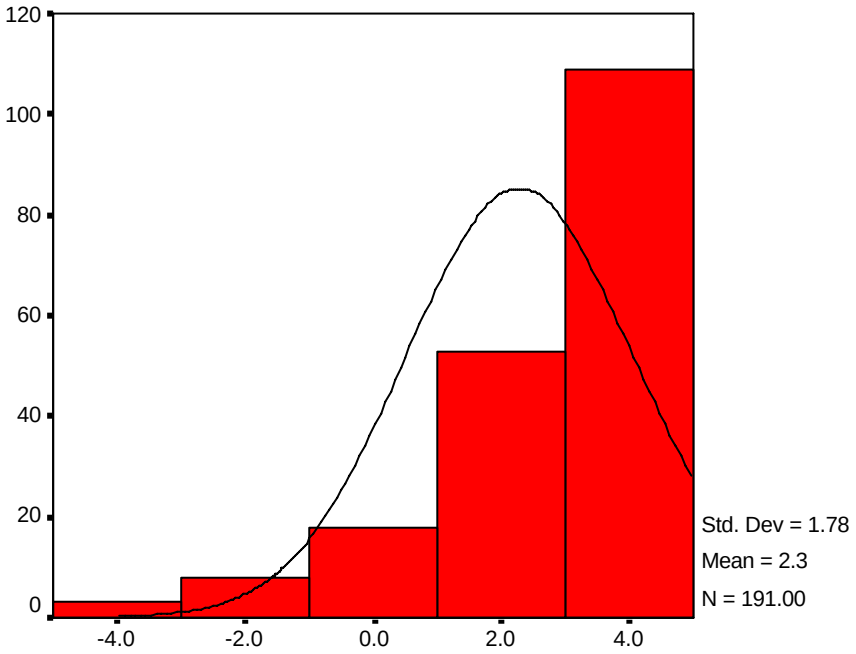

Figure 5.18 Question 2D Histogram & Normal Distribution

Question 2D gave a median value of 3.0 which equated to a very strong agreement with the statement that future levels of flight deck automation will lead to the requirement for a better education for new entrant pilots.

5.4.5 Question 2E – Advances in flight deck automation have led to changes in training methodologies

Mean Value	2.9
Median Value	3.0
Mode	4.0
Standard Deviation	1.22
Range	7.0
Minimum	-3.0
Maximum	4.0

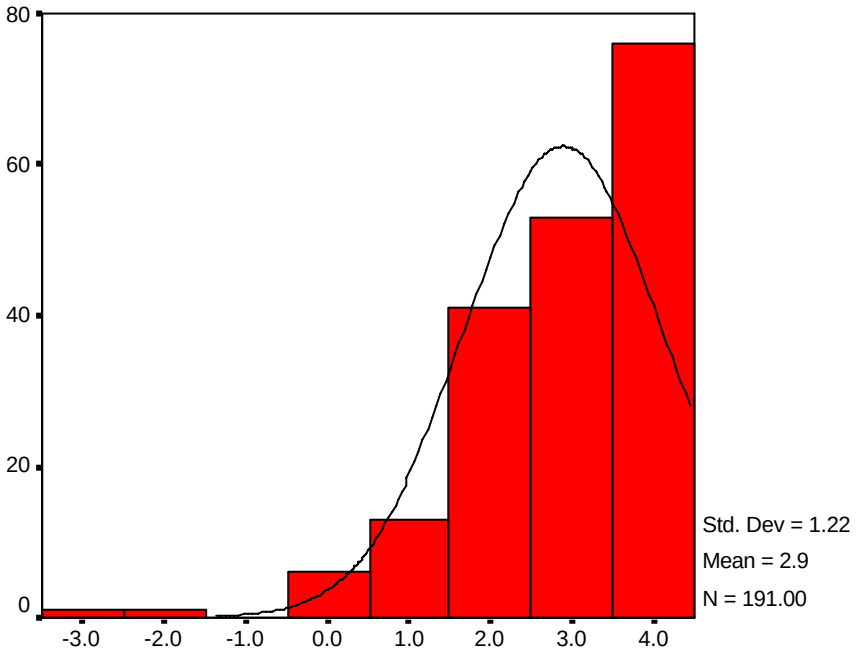

Figure 5.19 Question 2E Histogram & Normal Distribution

Question 2E gave a median value of 3.0 which equated to a very strong agreement with the statement that advances in flight deck automation have led to changes in training methodologies.

5.4.6 Question 2H – I have observed that pilots often experience difficulty monitoring or verifying the action that they have commanded of the flight deck automation during initial training on a new aircraft type

Mean Value	2.30
Median Value	3.0
Mode	3.0
Standard Deviation	1.46
Range	8.0
Minimum	-4.0
Maximum	4.0

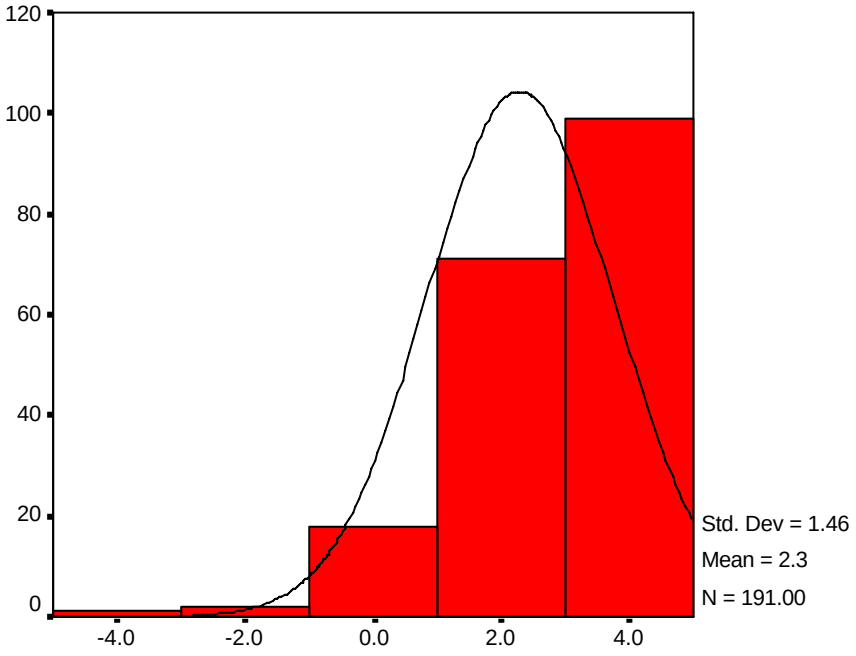

Figure 5.20 Question 2H Histogram & Normal Distribution

Question 2H gave a median value of 3.0 which equated to a very strong agreement with the observation that pilots often experience difficulty monitoring or verifying the action that they have commanded of the flight deck automation during initial training on a new aircraft type.

5.4.7 Question 2I – I have observed that pilots often experience difficulty formatting information so that the flight deck automation will accept and execute their commands during initial training on a new aircraft type

Mean Value	1.8
Median Value	2.0
Mode	2.0
Standard Deviation	1.58
Range	8.0
Minimum	-4.0
Maximum	4.0

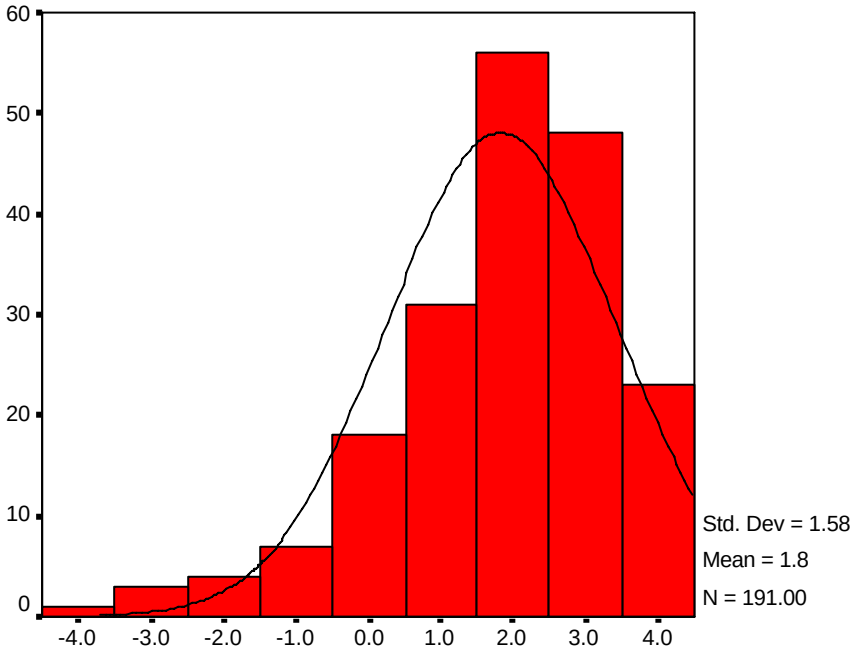

Figure 5.21 Question 2I Histogram & Normal Distribution

Question 2I gave a median value of 2.0 which equated to a strong agreement with the observation that pilots often experience difficulty formatting information so that the flight deck automation will accept and execute their commands during initial training on a new aircraft type.

5.4.8 Question 2J – I have observed that the effectiveness of training for procedures which require memorization has improved for highly automated aircraft as opposed to previous methods used in non-automated aircraft

Mean Value	0.8
Median Value	1.0
Mode	0.0
Standard Deviation	1.93
Range	8.0
Minimum	-4.0
Maximum	4.0

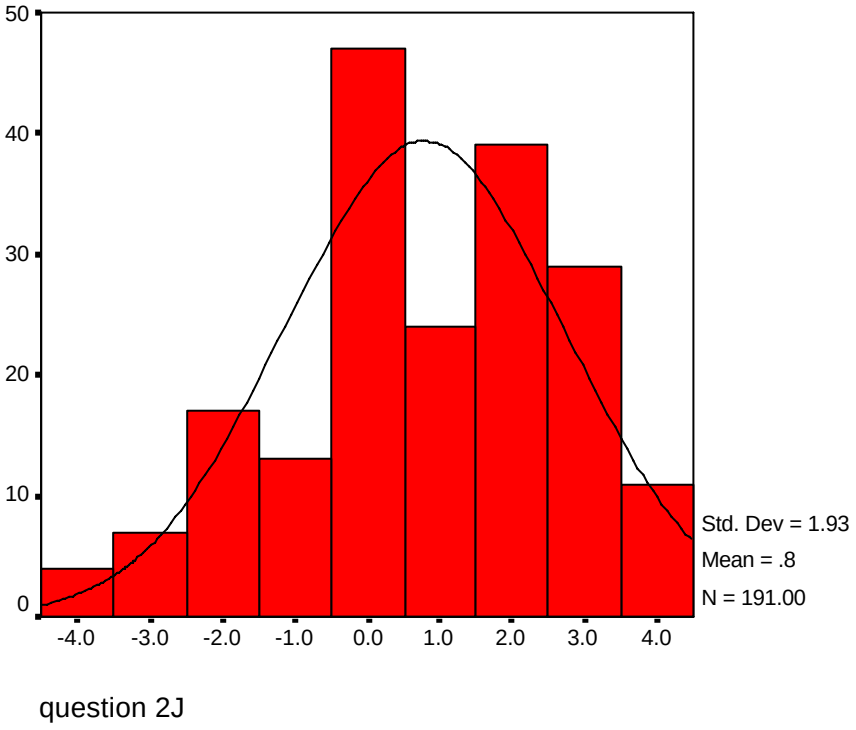

Figure 5.22 Question 2J Histogram & Normal Distribution

Question 2J gave a median value of 1.0 which equated to a moderate agreement with the observation that the effectiveness of training for procedures which require memorization has improved for highly automated aircraft as opposed to previous methods used in non-automated aircraft.

5.4.9 Question 2K – In my opinion changes in pilot skills and behaviour cannot always be detected through results of check flight programs

Mean Value	1.1
Median Value	2.0
Mode	2.0
Standard Deviation	2.17
Range	8.0
Minimum	-4.0
Maximum	4.0

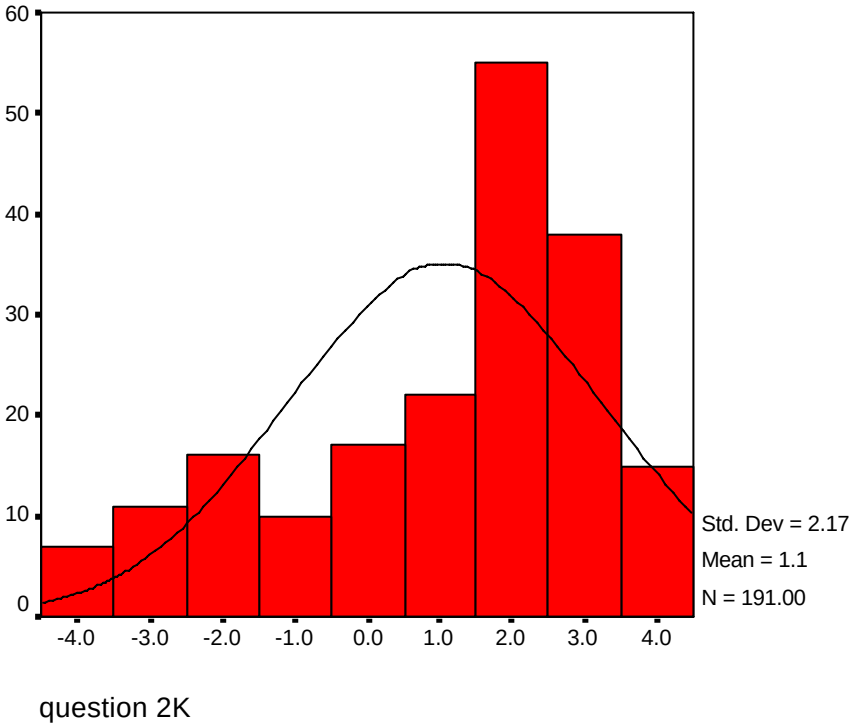

Figure 5.23 Question 2K Histogram & Normal Distribution

Question 2K gave a median value of 2.0 which equated with a strong agreement that changes in pilot skills and behaviour cannot always be detected through results of check flight programs.

5.4.10 Question 2L – I have observed that generally the workload of the pilot(s) increases with a corresponding increase in automation

Mean Value	-0.6
Median Value	-1.0
Mode	-2.0
Standard Deviation	2.42
Range	8.0
Minimum	-4.0
Maximum	4.0

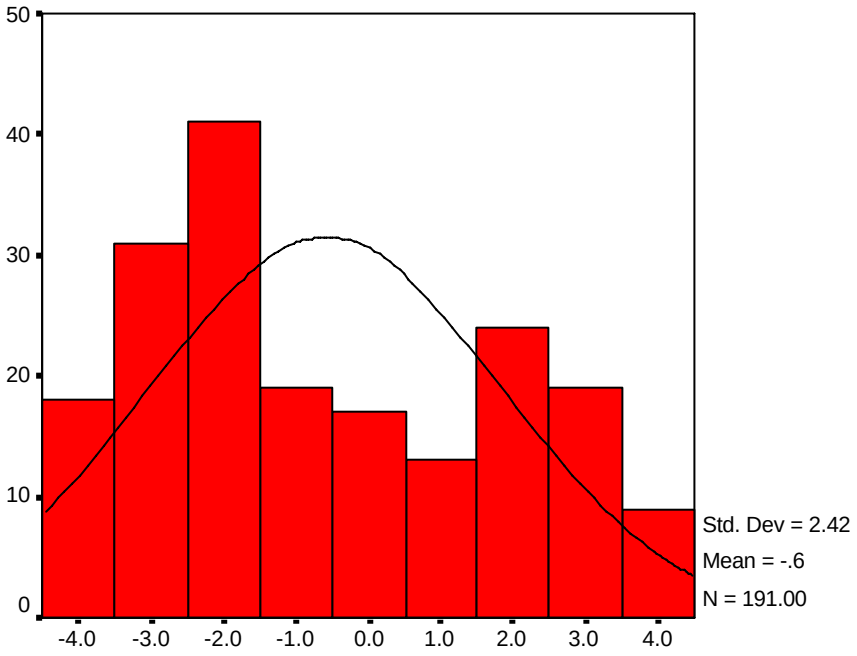

Figure 5.24 Question 2L Histogram & Normal Distribution

Question 2L gave a median value of -1.0 which equated to a moderate disagreement with the observation that generally the workload of the pilot(s) increases with a corresponding increase in automation.

5.4.11 Question 2M – I have observed that pilot workload due to a high level of flight deck automation decreases as the result of a higher level of training in aircraft systems knowledge and characteristics

Mean Value	1.2
Median Value	2.0
Mode	3.0
Standard Deviation	2.11
Range	8.0
Minimum	-4.0
Maximum	4.0

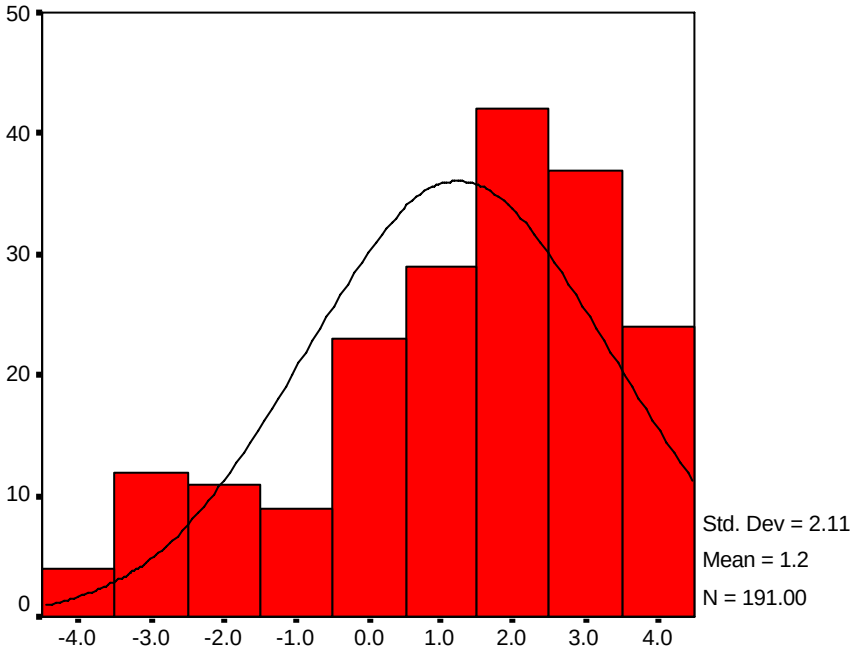

Figure 5.25 Question 2M Histogram & Normal Distribution

Question 2M gave a median value of 2.0 which equated to a strong agreement with the observation that pilot workload due to high level of flight deck automation decreases as a result of a higher level of training in aircraft systems knowledge and characteristics.

5.4.12 Section Two Analysis – Correlation of Questionnaire Results

Section Two pertained to the relationship between training requirements and advances made in flight deck automation.

5.4.13 Correlation between Question 2A and 2B

Question 2A asked the respondents whether advanced levels of flight deck automation have led to an increased level of training required for pilots. Question 2B asked if future levels of flight deck automation will lead to a decrease in the level of training required for pilots.

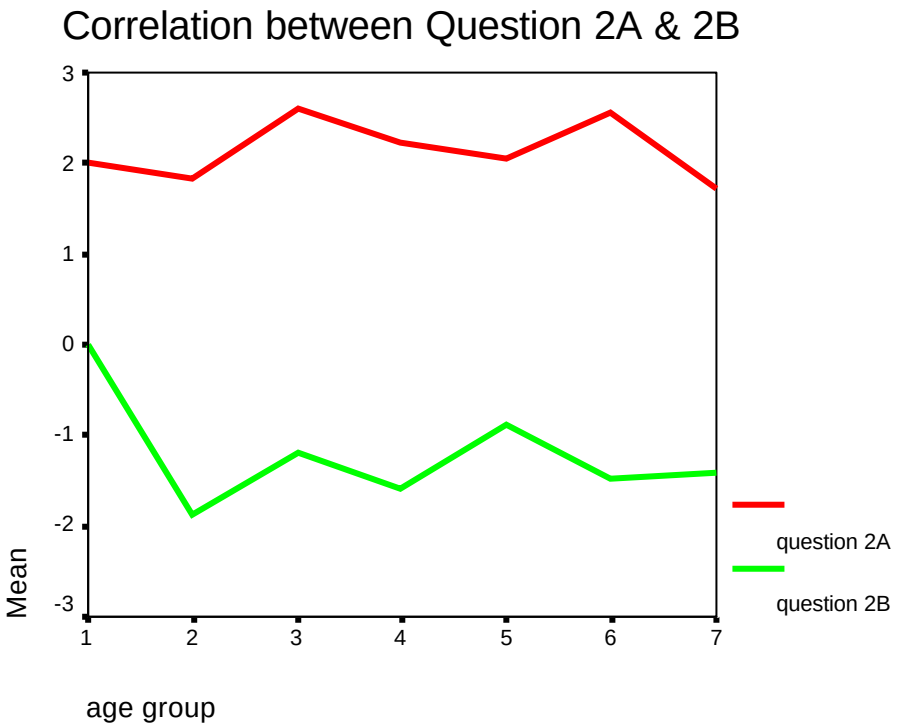

Figure 5.26 Correlations between Question 2A and 2B

Figure 5.26 shows that the individual mean value of each age group in question 2A was in a narrow band centred on the overall mean of 2.2 and an overall median of 2.0. This equates to strong agreement with the statement. In question 2B there was moderate to strong disagreement with the statement, again in a narrow band centred on the overall mean of -1.5 and median of -2.0. From these two questions it could be deduced that in the opinion of the industry respondents the level of training required for

pilots as a result of advanced levels of flight deck automation have increased and that there will be no possible future benefit of decreased levels of training required as a result of future levels of flight deck automation.

5.4.14 Correlation between Question 2C and 2D

Question 2C asks whether future levels of flight deck automation will lead to a lower flying experience level for new entrant pilots. From figure 5.27 it can be seen that in the lower age groups (1 & 2) there was neutral to very moderate agreement with this proposal where in the rest of the age groups the trend was towards moderate disagreement. The overall mean value was -0.3 and the median value was 0.0.

Question 2D asked whether future levels of flight deck automation will lead to the requirement for a better education level for new entrant pilots. Figure 5.27 shows that the lower age groups (1&2) show strong to very strong agreement with this proposal and that for the rest of the age groups the overall mean value of 2.3 was fairly consistent. Figure 5.18 shows the histogram for this question and highlights a median of 3.0.

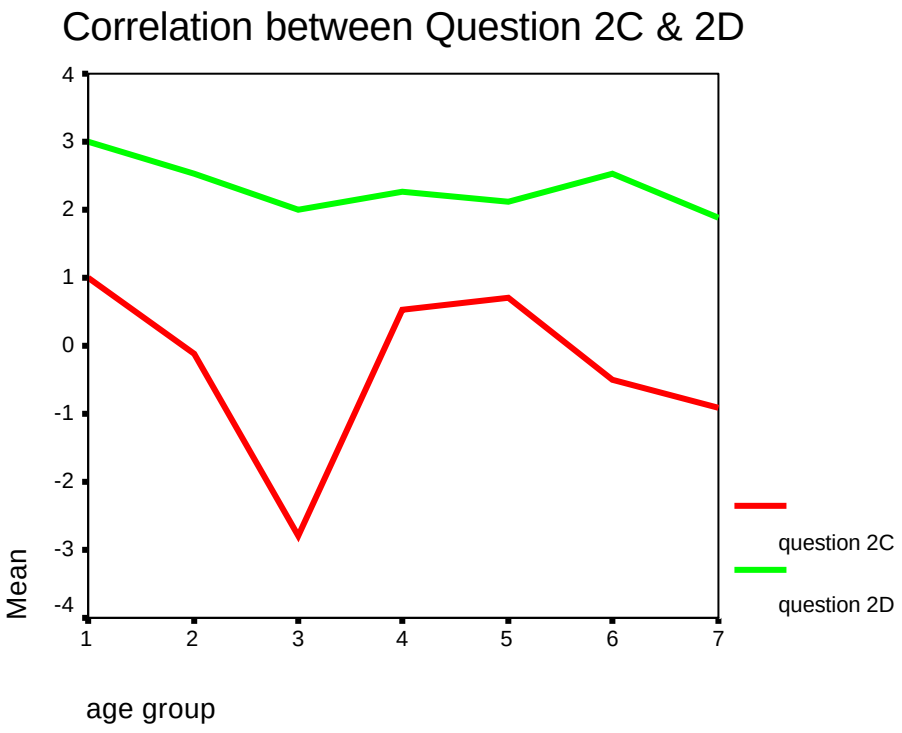

Figure 5.27 Correlations between Question 2C and 2D

From these two questions it can be seen that the opinion from the industry is that level of education for new entrants is gaining importance even in the older age groups who have generally spent a long time in the industry. Also any dramatic reductions in the flying experience level of new entrants as a result of future levels of flight deck automation are not readily foreseen.

5.4.15 Correlation between Question 2E, 2J and 2K

Question 2E asks whether advances in flight deck automation have led to changes in training methodologies. There is overall very strong agreement with this notion from all age groups. The overall mean value for this question shown in figure 5.19 is 2.9 and this is reasonably close to the individual mean values per age group that is shown below in figure 5.28.

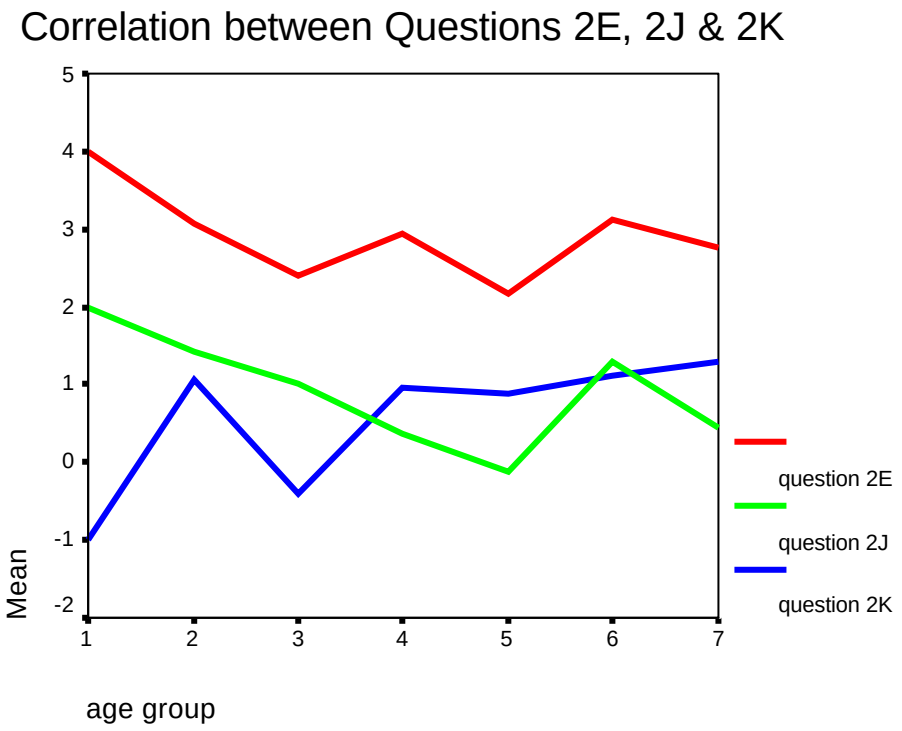

Figure 5.28 Correlations between Question 2E, 2J and 2K

Question 2J asks whether the effectiveness of training for procedures which require memorization has improved for highly automated aircraft as opposed to previous methods used in non-automated aircraft. Figure 5.28 shows the trend for agreement with this proposal as one that starts off being in strong agreement in the bottom age

group and reduces to somewhere between neutral and moderate agreement in the elder age groups. Figure 5.22 shows the overall mean value as 0.8 and the overall median as 1.0. These values seem fairly closely aligned with the individual mean values shown in figure 5.28. Basically it could be said that there is moderate agreement with the statement made in question 2J by the respondents.

Question 2K addresses the question of whether or not pilot skills and behaviour cannot always be detected through results of check flight programs. Figure 5.28 shows that there is an increasing trend towards moderate agreement with the statement in line with increasing age group and hence flying experience level. Figure 5.23 shows an overall mean value of 1.1 and an overall median of 2.0.

5.4.16 Correlation between Question 2H and 2I

Question 2H makes the statement 'I have observed that pilots often experience difficulty monitoring or verifying the actions that they have commanded of the flight deck automation during initial training on a new aircraft type'.

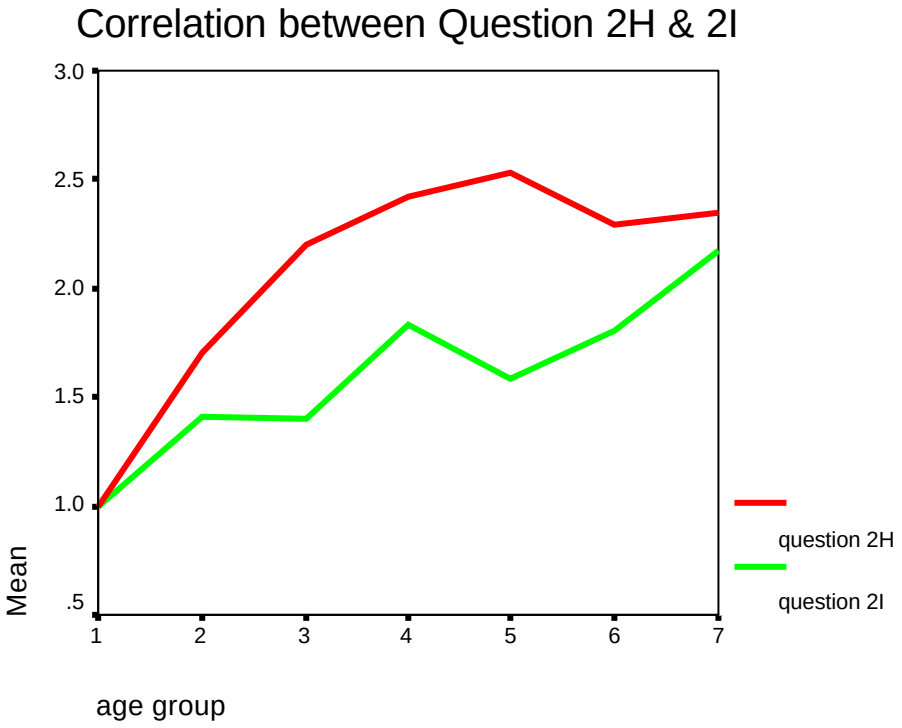

Figure 5.29 Correlations between Question 2H and 2I

Figure 5.29 shows an overall trend towards increasing agreement with this statement coincident with increasing age group. In all age groups the mean value of the respondents is positive and is in the range of moderate to strong or very strong. From figure 5.20 the overall mean value is 2.3 and the median is 3.0 therefore the overall indication from the respondents to this question is fairly clear.

Question 2I makes the statement 'I have observed that pilots often experience difficulty formatting information so that the flight deck automation will accept and execute their commands during initial training on a new aircraft type'. Figure 5.29 again shows an trend by and large towards increasing agreement with this statement coincident with increasing age group. In all age groups the mean value of the respondents is positive and is in the range of moderate to strong. From figure 5.21 the overall mean value is 1.8 and the median is 2.0 therefore once again the overall indication from the respondents to this question is clear. In the case of both of these questions new aircraft type transition courses appear to cause problems for pilots with respect to flight deck automation. It is no surprise nor is it a new observation that pilots undergoing training on a new aircraft which is highly automated have difficulties to provide associated with the understanding of and operations associated with flight deck automation which is new to them.

5.6.4 Correlation between Question 2L and 2M

Question 2L offers the statement 'I have observed that generally the workload of the pilot(s) increases with a corresponding increase in automation'. Figure 5.30 shows that the younger age group (1) is the only one which agrees with this statement and agrees very strongly. Age group one is however, a very small percentage of the respondents and this must be considered when accepting their responses. Every other age group shows a varying level of disagreement with the statement between neutral and moderate. From figure 5.24 the overall mean value of the respondents is -0.6 and the median is -1.0. This seems indicative of the attitude toward this statement as seen in figure 5.30.

Question 2M offers the statement 'I have observed that pilot workload due to a high level of flight deck automation decreases as the result of a higher level of training in aircraft systems knowledge and characteristics'. Interestingly figure 5.30 shows that

the lower age groups (1&2) do not have a strong opinion on this statement. However, as the age group increases the trend is generally for more agreement with this statement. Once again the element of flying experience and observation of problems in the past may play some part in the answer given by the elder respondents. Figure 5.25 shows that the overall mean value of the respondents is 1.2 and the median is 2.0.

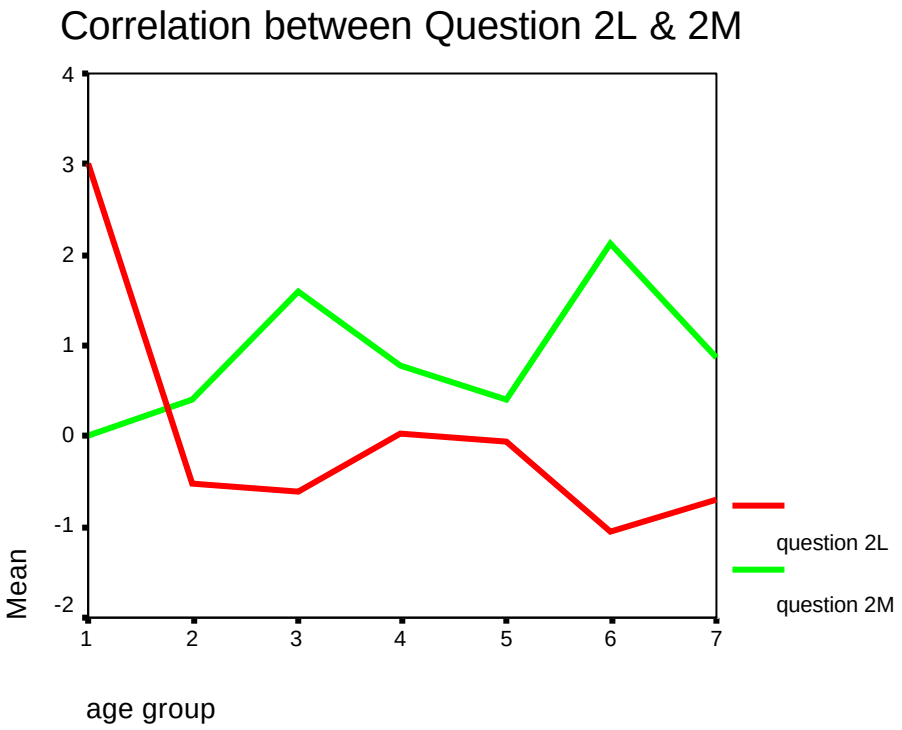

Figure 5.30 Correlations between Question 2L and 2M

These two questions are also very good indications of the opinion of experienced industry practitioners with respect to the observation is both current and past problems concerning flight deck automation. These responses are good sign posts for hazards that can probably be avoided with future hazards associated with advances in flight deck automation.

5.6.5 Summary - Section Two Analysis

In terms of potential hazards associated with future advances made in flight deck automation with respect to training issues section two of the questionnaire highlights the following observations:

1. From the results of the questionnaire the opinion of the industry respondents is such that the level of training required for pilots as a result of advanced levels of flight deck automation has increased.

2. There can be no possible future benefit gained through decreased levels of training required as a result of future levels of flight deck automation.

3. It can be seen that the opinion from the industry is that level of education for new entrants is gaining importance even in the older age groups who have generally spent a long time in the industry. Also any dramatic reductions in the flying experience level of new entrants as a result of future levels of flight deck automation are not readily foreseen.

4. Advances in flight deck automation have led to changes in training methodologies.

5. There is moderate agreement that the effectiveness of training for procedures which require memorization has improved for highly automated aircraft as opposed to previous methods used in non-automated aircraft.

6. There is moderate agreement that pilot skills and behaviour cannot always be detected through results of check flight programs.

7. Pilots do often experience difficulty monitoring or verifying the actions that they have commanded of the flight deck automation during initial training on a new aircraft type.

8. Pilots do often experience difficulty formatting information so that the flight deck automation will accept and execute their commands during initial training on a new aircraft type.

9. Pilot workload due to a high level of flight deck automation decreases as the result of a higher level of training in aircraft systems knowledge and characteristics. Generally the workload of the pilot(s) does not increase with a corresponding increase in automation.

5.5 Section Three of Questionnaire – Safety, Human Factors & Procedures

5.5.1 Question 3A – Future advances flight deck automation will lead to an increased level of safety for your operations

Mean Value	2.0
Median Value	2.0
Mode	2.0
Standard Deviation	1.71
Range	8.0
Minimum	-4.0
Maximum	4.0

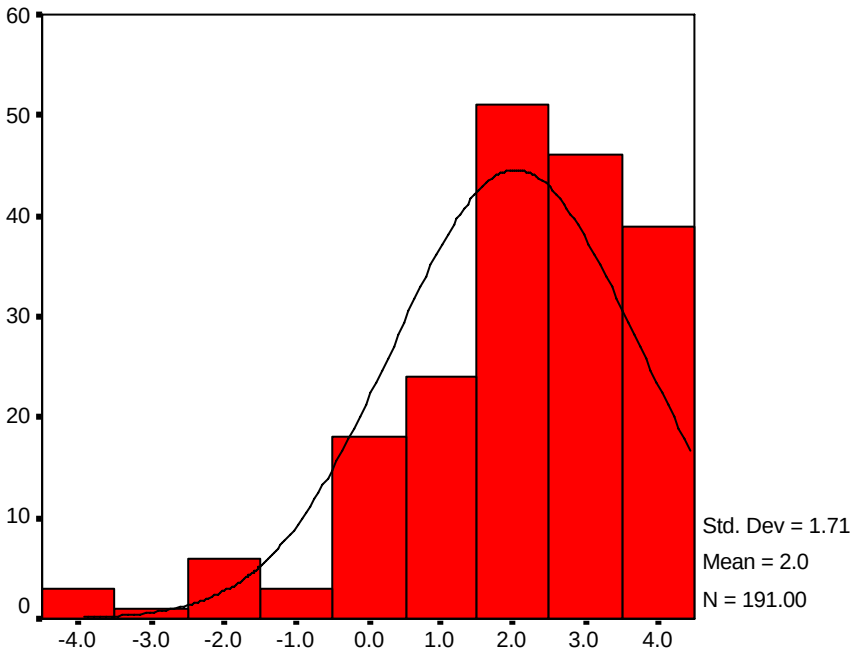

Figure 5.31 Question 3A Histogram & Normal Distribution

Question 3A gave a median value of 2.0 which equated to a strong agreement with the statement that future advances in flight deck automation will lead to an increased level of safety for your operations.

5.5.2 Question 3B – Future advances in flight deck automation will lead to problems maintaining “hands on” currency for pilots

Mean Value	1.6
Median Value	2.0
Mode	2.0
Standard Deviation	1.92
Range	8.0
Minimum	-4.0
Maximum	4.0

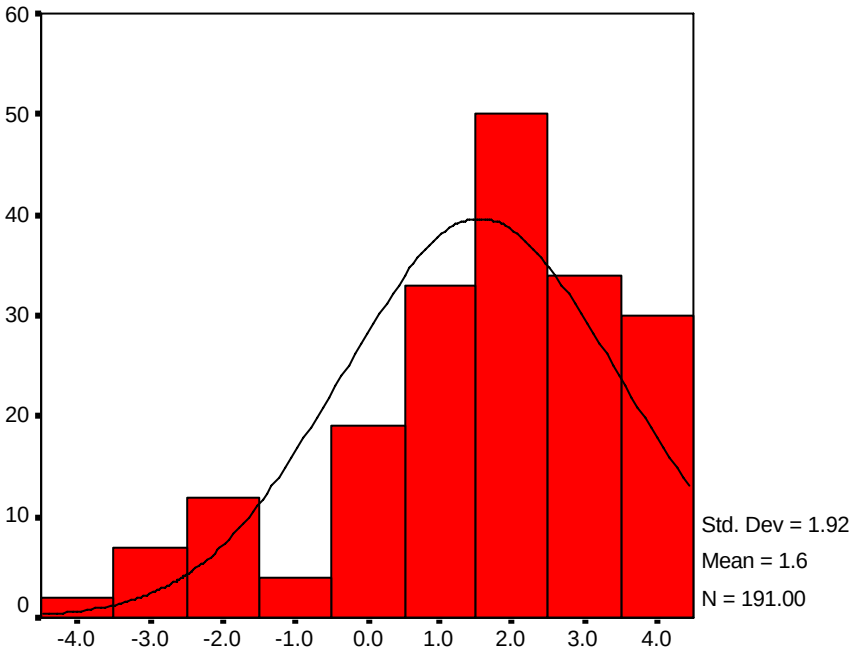

Figure 5.32 Question 3B Histogram & Normal Distribution

Question 3B gave a median value of 2.0 which equated to a strong agreement with the statement that future advances in flight deck automation will lead to problems maintaining “hands on” currency for pilots.

5.5.3 Question 3C – Increased reliance on flight deck automation by pilots has led to potentially lower levels of safety for your type of airline operation

Mean Value	-1.3
Median Value	-2.0
Mode	-3.0
Standard Deviation	2.09
Range	8.0
Minimum	-4.0
Maximum	4.0

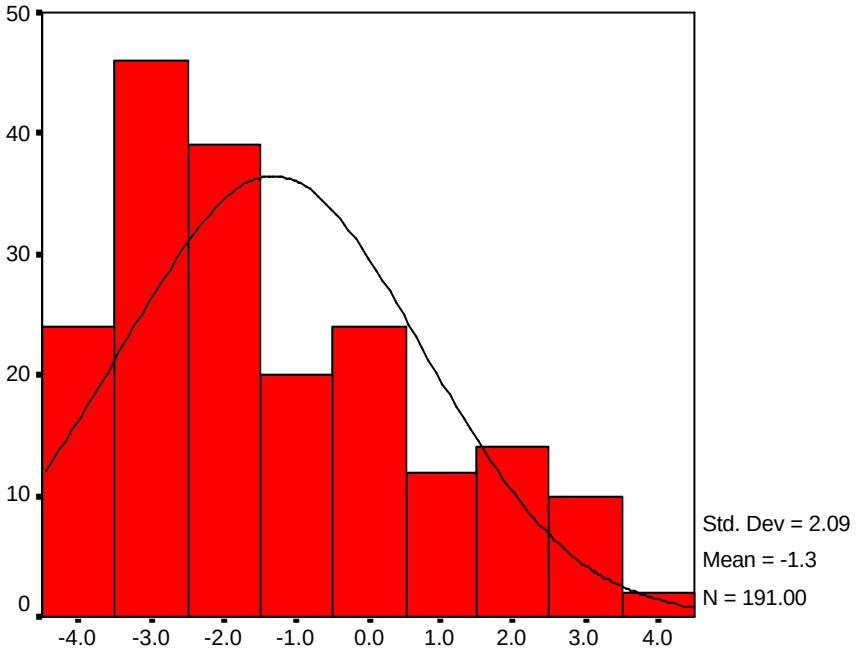

Figure 5.33 Question 3C Histogram & Normal Distribution

Question 3C gave a median value of -2.0 which equated to a strong disagreement with the statement that increased reliance on flight deck automation by pilots has led to potentially lower levels of safety for your type of airline operation.

5.5.4 Question 3D – Advanced levels of flight deck automation are increasing the amount of useful information available to pilots

Mean Value	2.4
Median Value	3.0
Mode	3.0
Standard Deviation	1.65
Range	8.0
Minimum	-4.0
Maximum	4.0

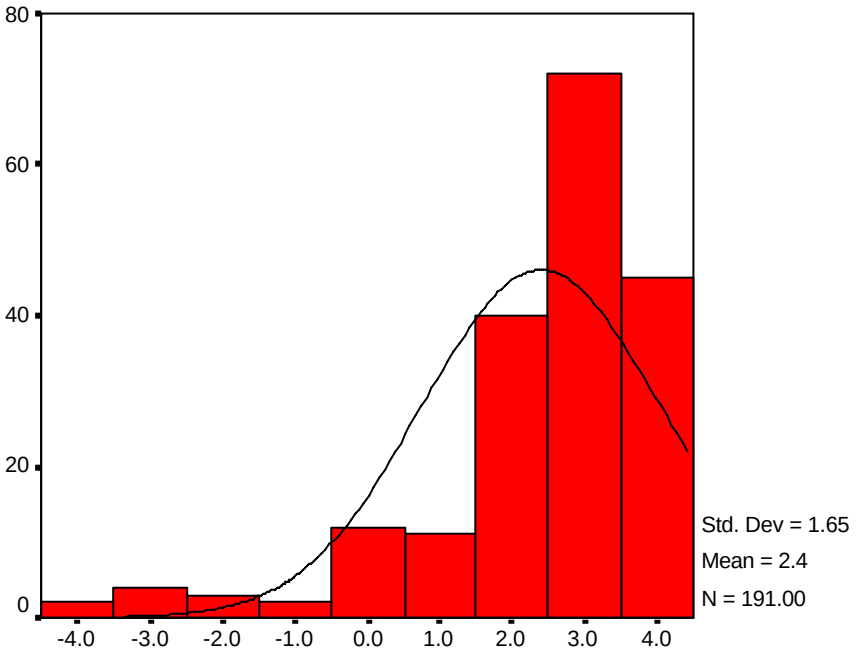

Figure 5.34 Question 3D Histogram & Normal Distribution

Question 3D gave a median value of 3.0 which equated to a very strong agreement with the statement that advanced levels of flight deck automation are increasing the amount of useful information available to pilots.

5.5.5 Question 3E – Future advances in flight deck automation will enhance situational awareness for pilots

Mean Value	1.8
Median Value	2.0
Mode	3.0
Standard Deviation	1.83
Range	8.0
Minimum	-4.0
Maximum	4.0

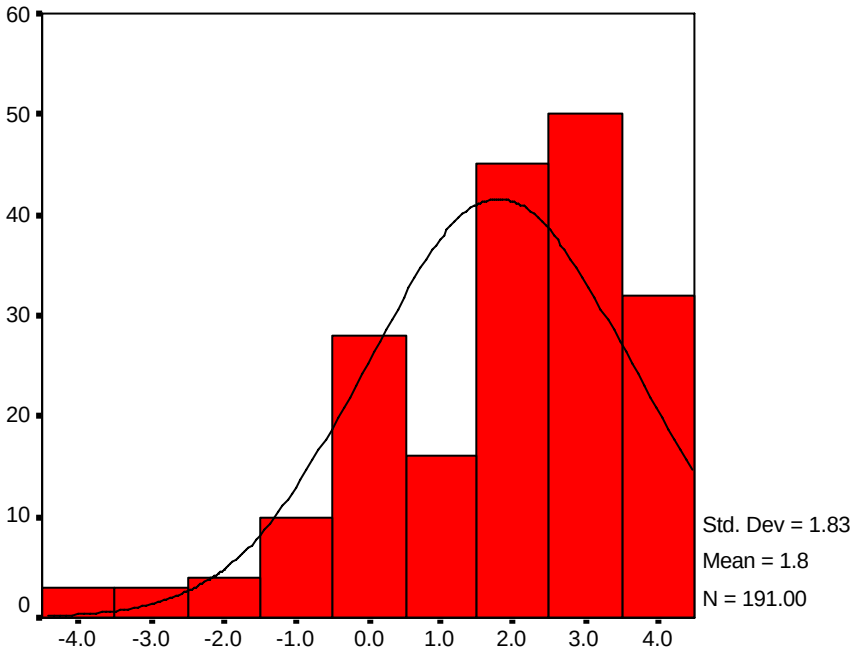

Figure 5.35 Question 3E Histogram & Normal Distribution

Question 3E gave a median value of 2.0 which equated to a strong agreement with the statement that future advances in flight deck automation will enhance situational awareness for pilots.

5.5.6 Question 3F – Sometimes the response/behaviour of the aircraft (due to the level of flight deck automation) surprises me

Mean Value	0.1
Median Value	1.0
Mode	1.0
Standard Deviation	2.22
Range	8.0
Minimum	-4.0
Maximum	4.0

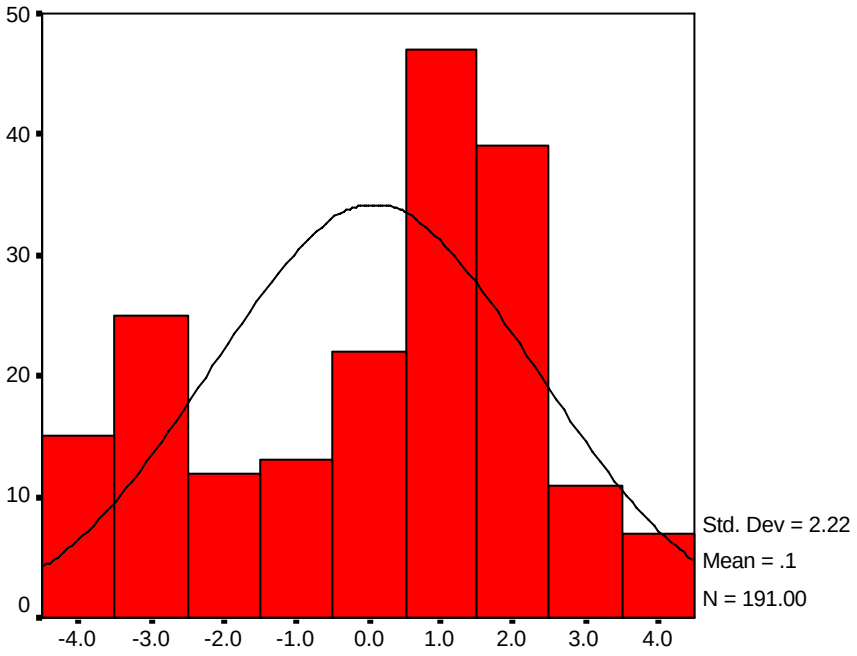

Figure 5.36 Question 3F Histogram & Normal Distribution

Question 3F gave a median value of 1.0 which equated to a moderate agreement with the statement that sometimes the response/behaviour of the aircraft due to the level of flight deck automation surprises me.

5.5.7 Question 3H – In my observations pilot behaviour and level of aircraft system knowledge is improving as a result of progress in computer software and technology development

Mean Value	0.80
Median Value	1.0
Mode	2.0
Standard Deviation	2.16
Range	8.0
Minimum	-4.0
Maximum	4.0

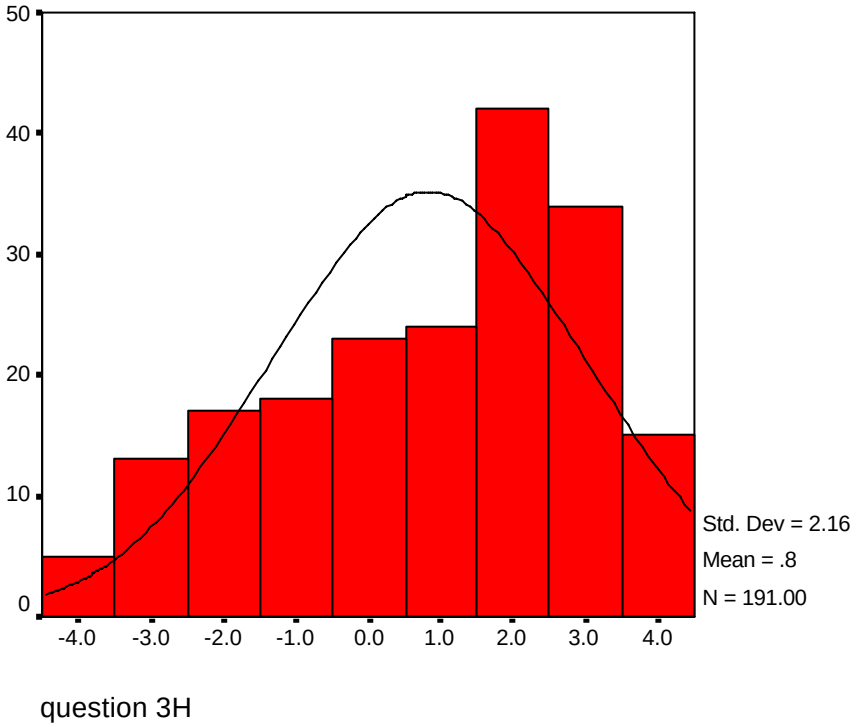

Figure 5.37 Question 3H Histogram & Normal Distribution

Question 3H gave a median value of 1.0 which equated to a moderate agreement with the observation that pilot behaviour and level of aircraft system knowledge is improving as a result of progress in computer software and technology development.

5.5.8 Question 3I – In my observations there are more memory items required for pilots of highly automated aircraft as opposed to non-automated (previous generation) aircraft.

Mean Value	-1.0
Median Value	-2.0
Mode	2.0
Standard Deviation	2.30
Range	8.0
Minimum	-4.0
Maximum	4.0

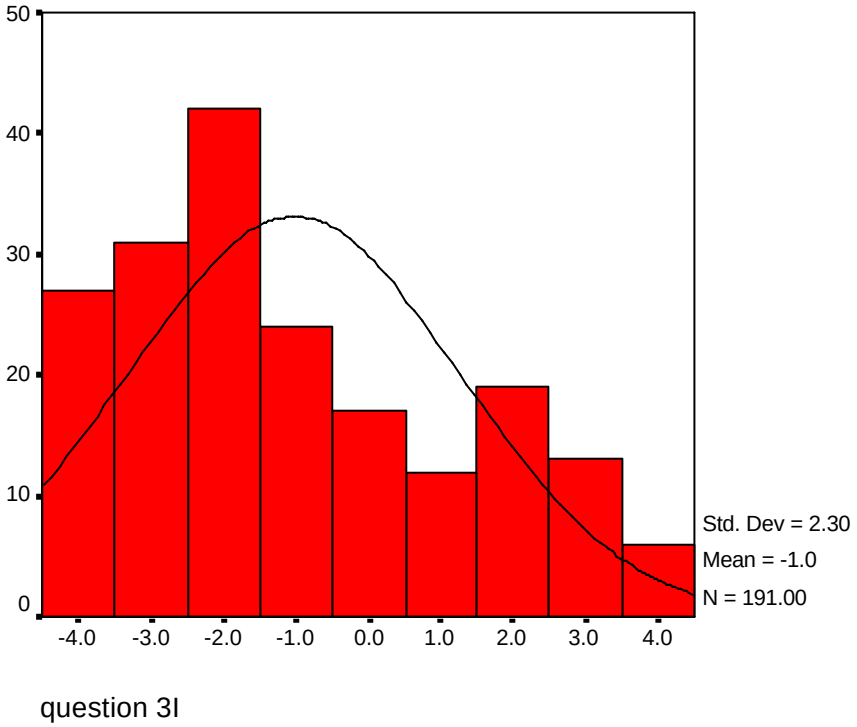

Figure 5.38 Question 3I Histogram & Normal Distribution

Question 3I gave a median value of -2.0 which equated to a strong disagreement with the observation that there are more memory items required for pilots of highly automated aircraft as opposed to non-automated (previous generation) aircraft.

5.5.9 Question 3J – Automation in the cockpit reduces the difference of role between Captain and First Officer

Mean Value	-0.9
Median Value	-1.5
Mode	-4.0
Standard Deviation	2.58
Range	8.0
Minimum	-4.0
Maximum	4.0

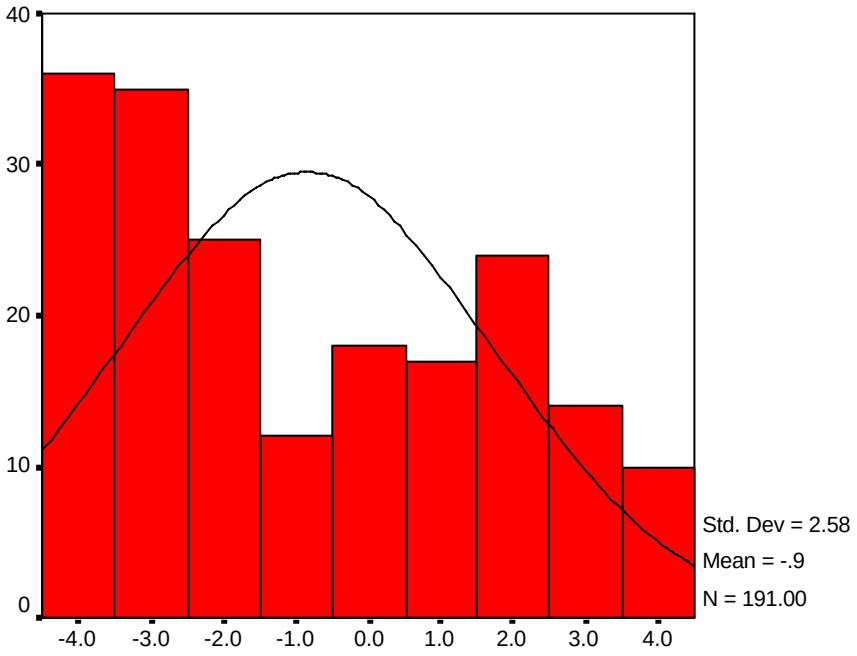

Figure 5.39 Question 3J Histogram & Normal Distribution

Question 3J gave a median value of -1.5 which equated to a moderate to strong disagreement with the statement that automation in the cockpit reduces the difference of role between Captain and First Officer.

5.5.10 Question 3K – In my observations pilots are less stressed after a day's work in a highly automated cockpit compared to non-automated (previous generation) aircraft

Mean Value	1.1
Median Value	2.0
Mode	3.0
Standard Deviation	2.50
Range	8.0
Minimum	-4.0
Maximum	4.0

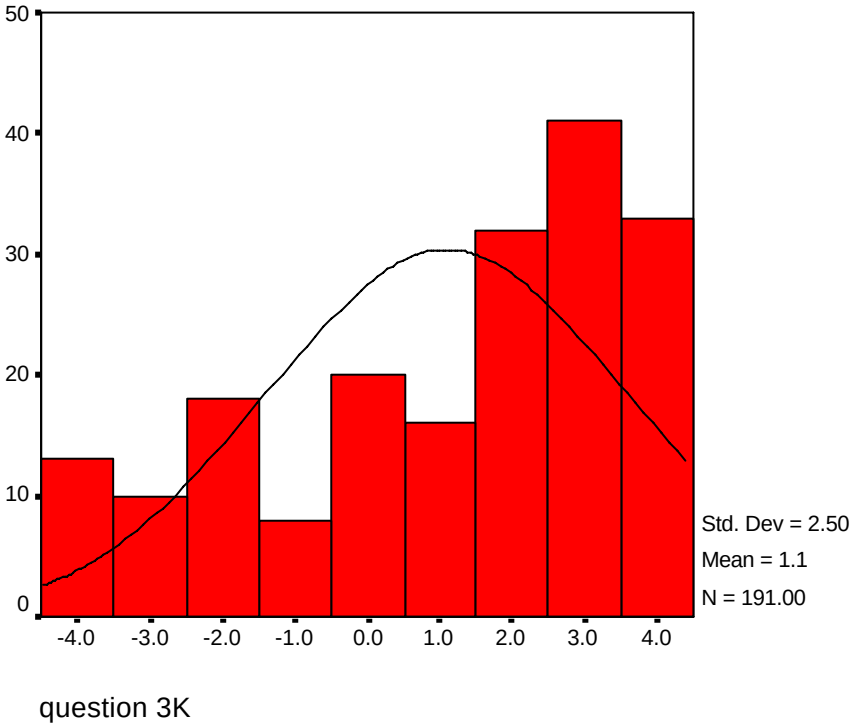

Figure 5.40 Question 3K Histogram & Normal Distribution

Question 3K gave a median value of 2.0 which equated to a strong agreement with the observation that pilots are less stressed after a day's work in a highly automated cockpit compared to non-automated (previous generation) aircraft.

5.5.11 Question 3L – In my opinion the level of stress and fatigue increases rapidly when flight crew do not fully understand what operation the flight deck automation is commanding the aircraft to perform

Mean Value	2.80
Median Value	3.0
Mode	4.0
Standard Deviation	1.46
Range	7.0
Minimum	-3.0
Maximum	4.0

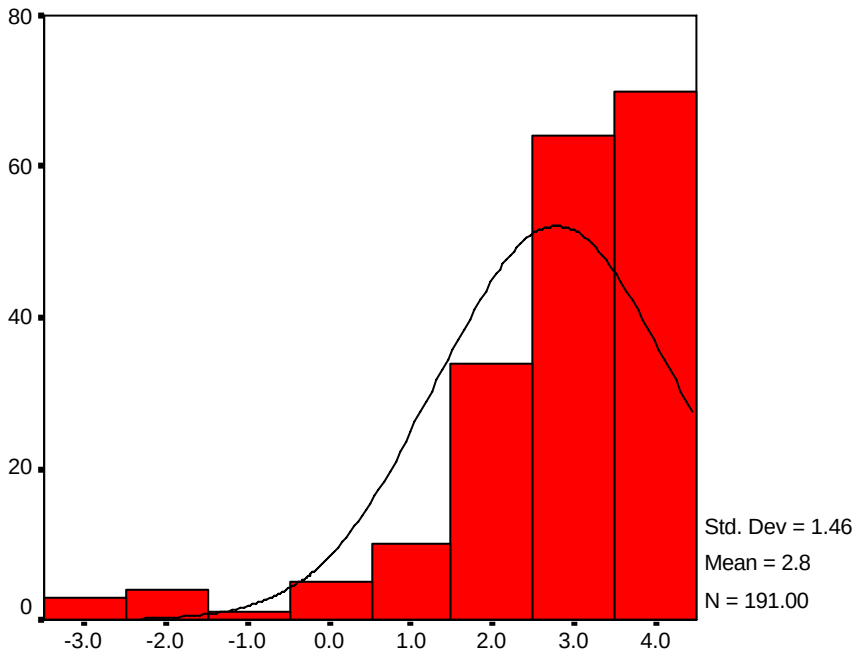

Figure 5.41 Question 3L Histogram & Normal Distribution

Question 3L gave a median value of 3.0 which equated to a very strong agreement with the opinion that the level of stress and fatigue increases rapidly when flight crew do not fully understand what operation the flight deck automation is commanding the aircraft to perform.

5.5.12 Question 3M – I have observed that some automated functions designed into aircraft have a tendency to cause misunderstanding or hesitation by a significant number of pilots

Mean Value	1.33
Median Value	2.0
Mode	2.0
Standard Deviation	1.96
Range	8.0
Minimum	-4.0
Maximum	4.0

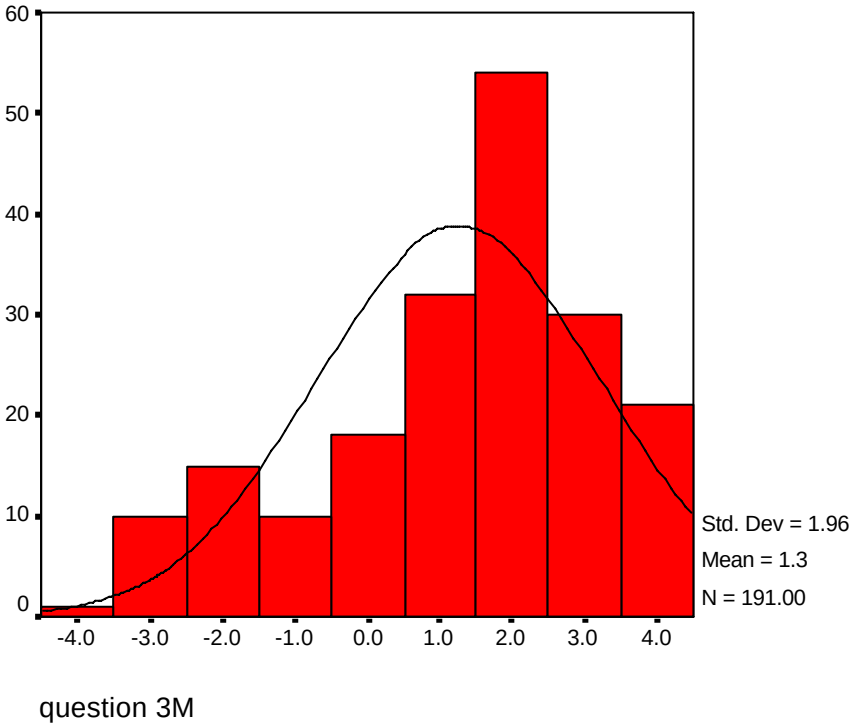

Figure 5.42 Question 3M Histogram & Normal Distribution

Question 3M gave a median value of 2.0 which equated to a strong agreement with the observation that some automated functions designed into aircraft have a tendency to cause misunderstanding or hesitation by a significant number of pilots.

5.5.13 Question 3N – I have observed that some automated functions designed into aircraft have a tendency to cause misunderstanding or hesitation by a significant number of pilots

Mean Value	1.0
Median Value	1.0
Mode	2.0
Standard Deviation	1.94
Range	8.0
Minimum	-4.0
Maximum	4.0

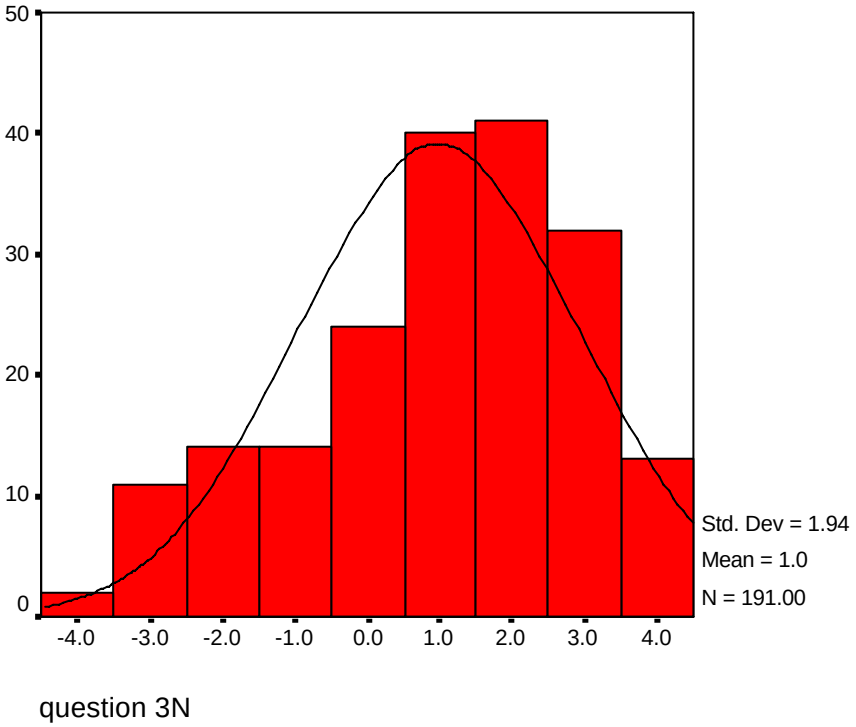

Figure 5.43 Question 3N Histogram & Normal Distribution

Question 3N gave a median value of 1.0 which equated to a moderate agreement with the observation that some automated functions designed into aircraft have a tendency to cause misunderstanding or hesitation by a significant number of pilots.

5.5.14 Question 3O – As a result of advances in flight deck automation what is the minimum number of technical crew (pilots) that you would expect to be necessary to operate a large passenger aircraft on long distance flights?

Mean Value	1.9
Median Value	2.0
Mode	2.0
Standard Deviation	1.10
Range	4.0
Minimum	0.0
Maximum	4.0

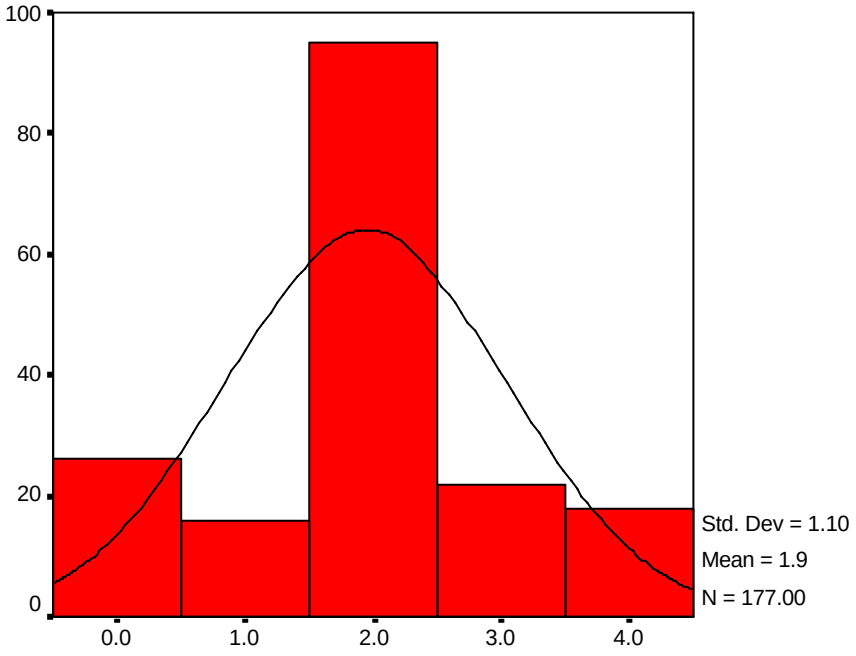

Figure 5.44 Question 3O Histogram & Normal Distribution

Question 3O showed that average opinion was that as a result of advances in flight deck automation the minimum number of technical crew expected to be necessary to operate a large passenger aircraft on long distance flights is 2.

5.5.15 Section Three Analysis – Correlation of Questionnaire Results

Section Three pertained to the relationship between safety, human factors, operational procedures and advances made in flight deck automation.

5.5.16 Correlation between Question 3A, 3B and 3C

Question 3A poses the statement that advances in flight deck automation will lead to an increase in level of safety for your respective operation. Question 3C similarly puts the proposal forward that increased reliance on flight deck automation by pilots has led to potentially lower levels of safety for your type of airline operation. Question 3B asks respondents to agree or disagree on whether future advances in flight deck automation will lead to problems maintaining 'hands on' currency for pilots.

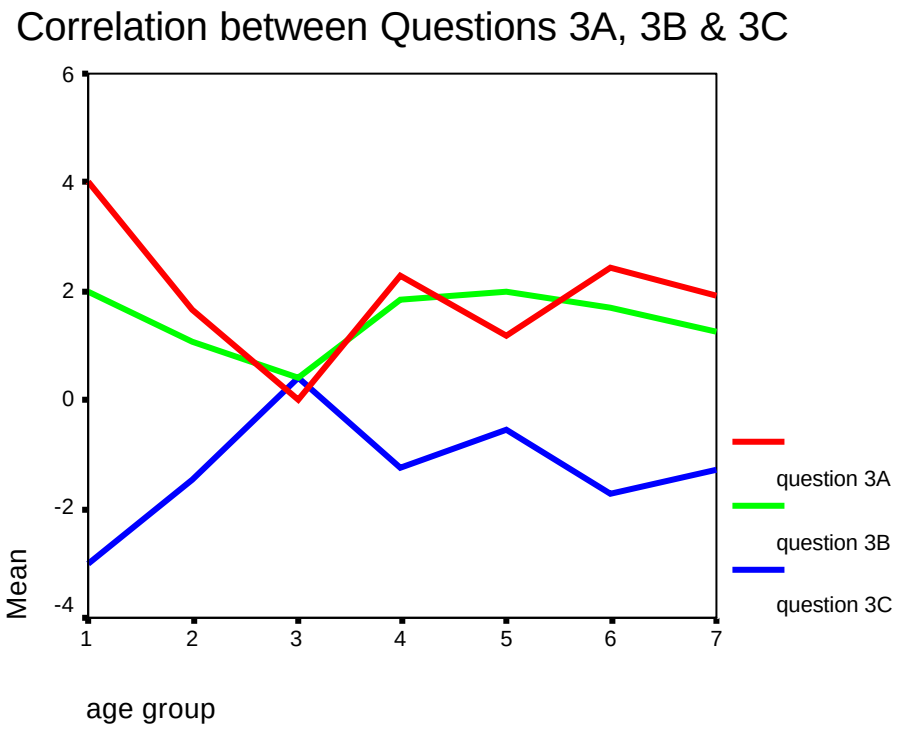

Figure 5.45 Correlations between Questions 3A, 3B and 3C

In question 3A there is a slight trend is towards a lower level of agreement with the statement with increase in age group. No real disagreement with the statement is evident therefore it can be said that the pilots surveyed generally have strong

agreement with the concept that future advances in flight deck automation will lead to increased safety. As previously stated age groups 1 and 3 are an extremely small proportion of the overall respondents. The overall mean value for this question from figure 5.31 was 2.0 and the overall median was 2.0. This is reflected in the individual mean values shown in figure 5.45.

In question 3C overall the trend is toward a lower level of disagreement with the statement with increase in age group. However, generally it can be said that there is a moderate to strong disagreement with the proposal that increased reliance on flight deck automation has led to potentially lower levels of safety. The overall mean value from figure 5.33 is -1.3 and the overall median is -2.0.

In Question 3B there is a general consensus that there will be problems maintaining 'hands on' currency due to future advances in flight deck automation. Overall it could be said that there is moderate to strong agreement with this proposal. From figure 5.32 the overall mean value is 1.6 and the median is 2.0.

So from these three questions it can be said that the respondents believe that advances in flight deck automation will lead to 'hands on' currency for pilots being adversely affected however, levels of safety will be increased and not potentially reduced as a result.

5.5.17 Correlation between Question 3D and 3E

Figure 5.46 shows the graphs of mean values for questions 3D and 3E with respect to age group. Question 3D related to whether advanced levels of flight deck automation is increasing the amount of useful information available to pilots. There is agreement with this concept for all age groups. In age groups 6 and 7 where the majority of the respondents are located the level of agreement is strong to very strong. The overall mean value from figure 5.34 is 2.4 and the median is 3.0.

For question 3E the graph takes a similar shape to that of question 3D however, the mean value of level of agreement is not as high. Once again there is agreement with this proposal for all age groups. The overall mean value from figure 5.35 is 1.8 and the median is 2.0. Thus it can be said that there is moderate to strong agreement with

the statement that future advances in flight deck automation will enhance situational awareness.

This is an interesting response considering there is a strong to very strong agreement that advanced levels of flight deck automation are increasing the amount of useful information available to pilots however there is only moderate to strong agreement that situational awareness will be enhanced.

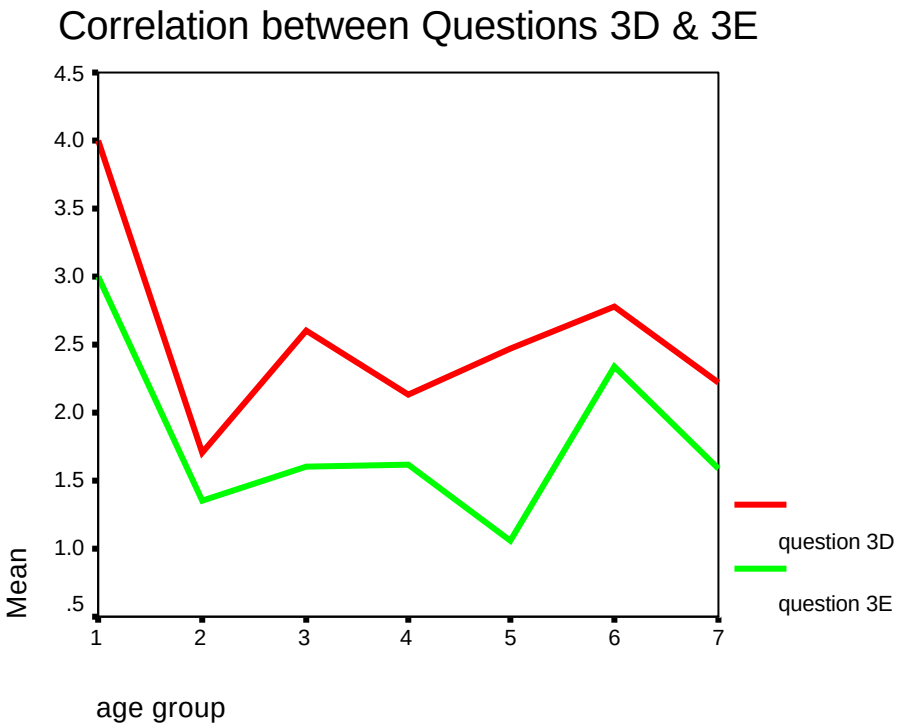

Figure 5.46 Correlations between Questions 3D and 3E

5.5.18 Correlation between Question 3F, 3M and 3N

Question 3F offers the statement that 'sometimes the response/behaviour of the aircraft (due to the level of flight deck automation) surprises me'. Question 3M makes the statement 'I have observed that some automated functions designed into aircraft have a tendency to cause misunderstanding or hesitation by a significant number of pilots'. Figure 5.47 shows the relationship between the responses for these two questions.

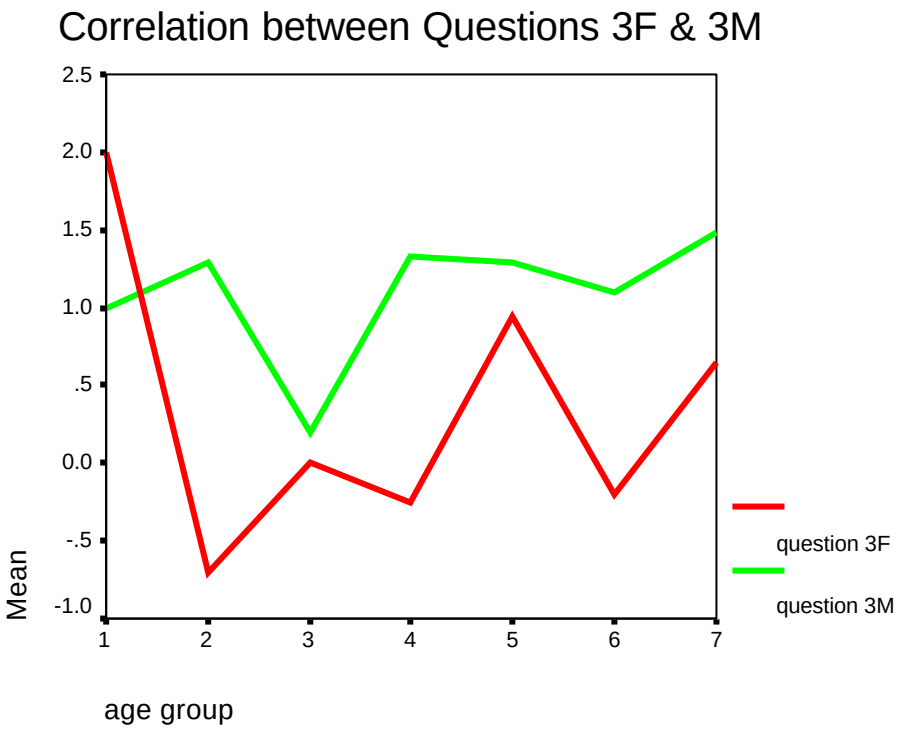

Figure 5.47 Correlations between Questions 3F and 3M

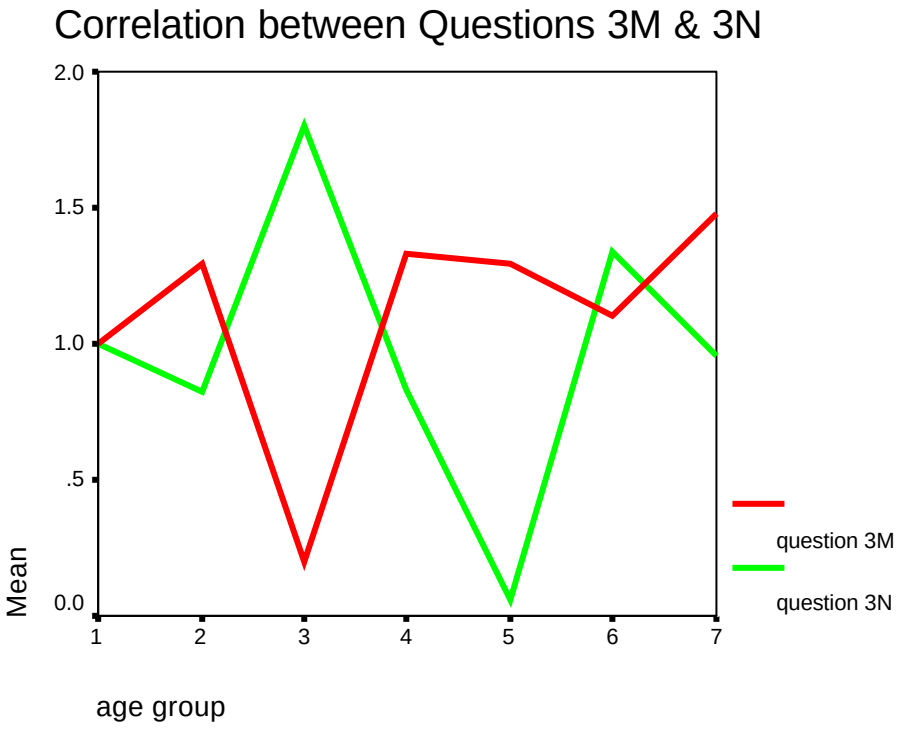

Figure 5.48 Correlations between Questions 3M and 3N

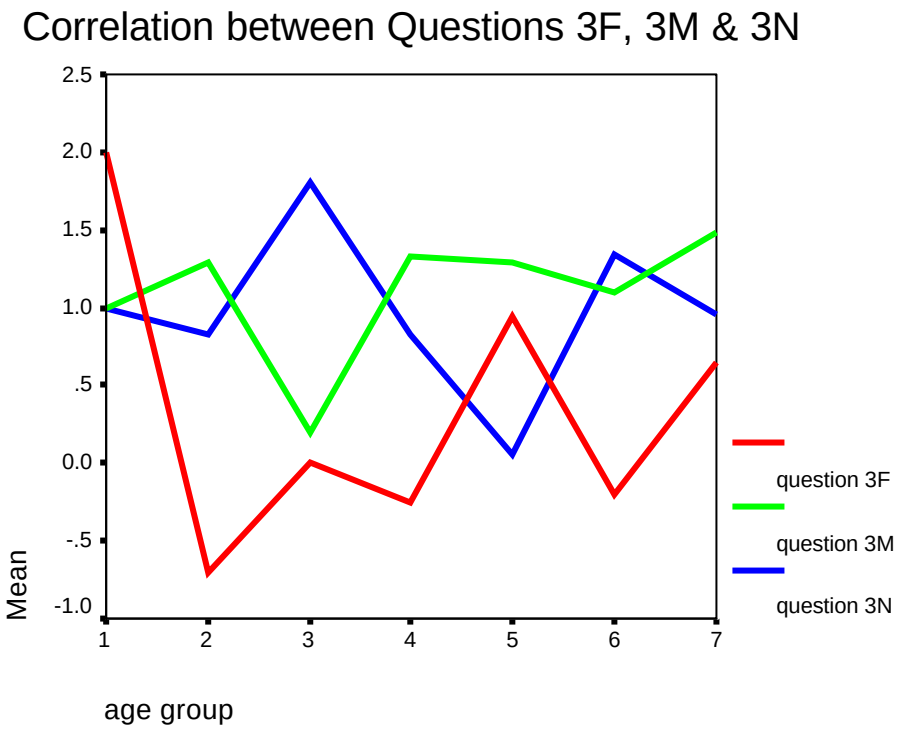

Figure 5.49 Correlations between Questions 3F, 3M and 3N

In question 3F the results show a high agreement with the statement in the first age group and then from age group 2 onwards there is a trend towards a higher level of agreement albeit only low to moderate. Once again considering the fact that only a very small proportion of the respondents were in age groups one and three it can be said that there is a general tendency towards an increase in agreement with the proposal with increase in age group. From figure 5.36 the overall mean value is 0.1 and the median is 1.0.

Question 3M shows a similar trend from moderate to strong agreement with the proposal that some automated functions cause misunderstanding or hesitation by pilots. From figure 5.42 the overall mean value is 1.33 and the median is 2.0.

Question 3N shows basically moderate agreement with the suggestion that some automated functions are straight forward and understood instinctively by pilots. From figure 5.43 the overall mean value is 1.0 and the median is 1.0.

From these three questions concerning to the relationship between the human operator (pilot) and the automated functions associated with the modern flight deck there

appears to be no overriding opinion either way or just a mainly moderate agreement with the proposals. Quite possibly the human operator (pilot) has been exposed to such a level of flight deck automation for a such a period of time now that it no longer presents such a critical issue to them in general.

5.5.19 Correlation between Question 3H and 3I

Question 3H suggests that pilot behaviour and aircraft system knowledge is improving as a result of progress in computer software and technology development. There is agreement with this proposal ranging from strong in age group one to moderate in age group seven. Taking into account the fact again that the sample age groups from one and three are very small the trend could possibly be seen as upwards, however, only on a slight scale. Generally it could be said that there is moderate agreement with this suggestion. From figure 5.37 the overall mean value is 0.8 and the median is 1.0.

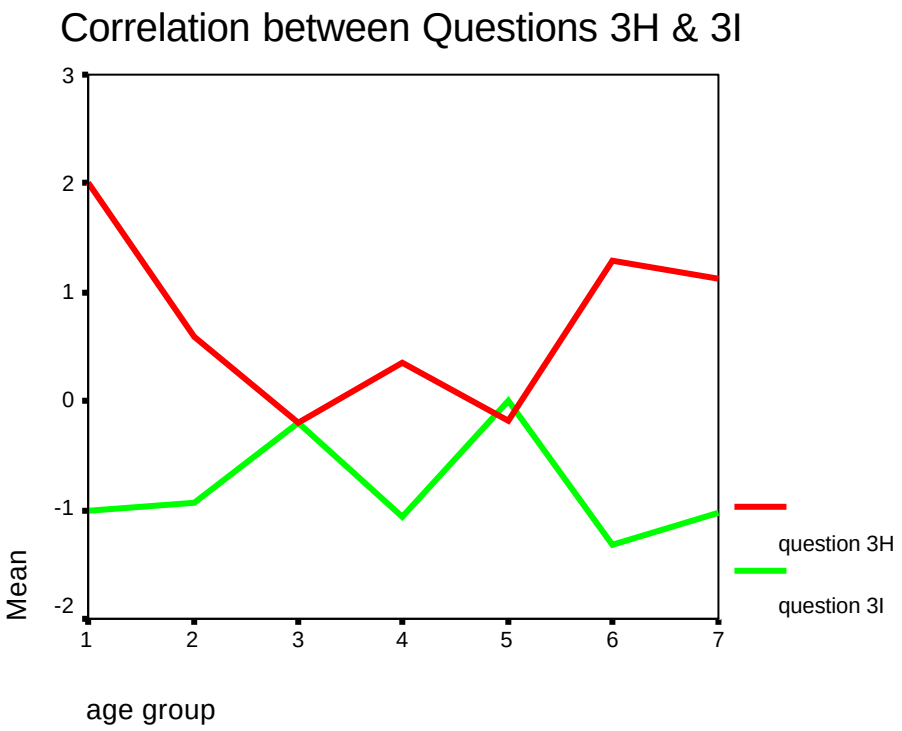

Figure 5.50 Correlations between Questions 3H & 3I

Question 3I suggests that there are more memory items required for pilots of highly automated aircraft than previous generation ones. There is moderate disagreement

with this proposal. This response is in line with the general philosophy of highly automated aircraft where most actions and recall items such as engine shutdowns, propeller auto feathering, electrical load shedding etc are done automatically. From figure 5.38 the overall mean value is -1.0 and the median is -2.0.

5.5.20 Correlation between Question 3K and 3L

Stress is something that is synonymous with the role of the pilot. Questions 3K and 3L address this issue. Question 3K suggests that pilots are less stressed after a day's work in a highly automated cockpit compared to previous generation aircraft.

There is concurrence with this proposal however; the overall trend is towards a lower level of agreement as the age group increases. Generally it can be said that there is moderate agreement with this proposal. From figure 5.40 the overall mean value is 1.1 and the median is 2.0.

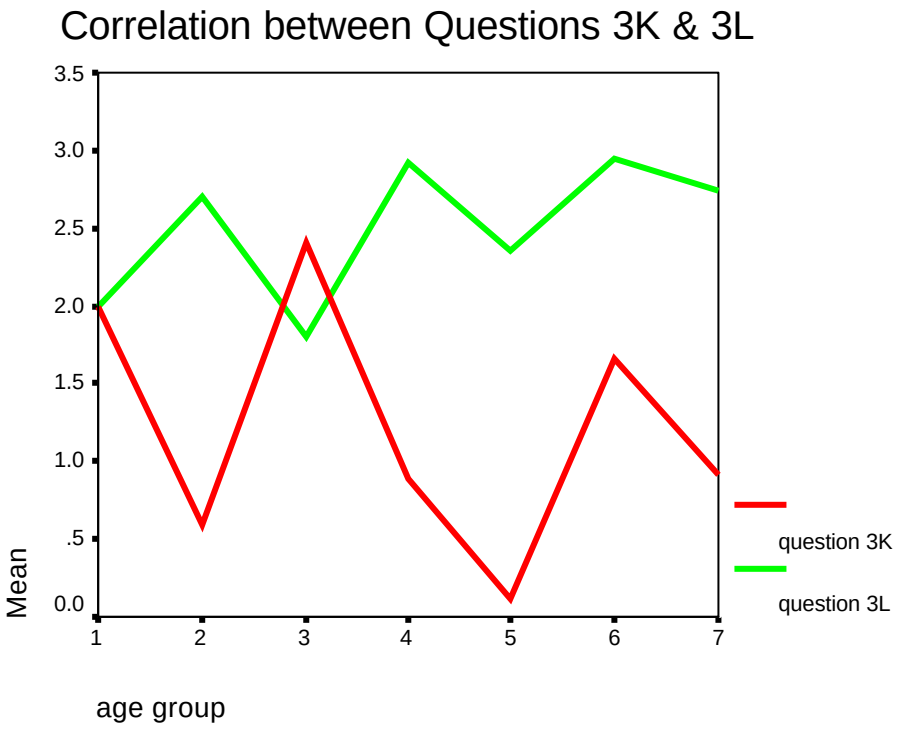

Figure 5.51 Correlations between Questions 3H & 3I

Question 3L offers the opinion that stress and fatigue increases rapidly when the flight crew do not fully understand what the flight deck automation is asking the aircraft to do. There is a very positive response from all age groups to this suggestion with strong to very strong agreement. From figure 5.41 the overall mean value is 2.8 and the median is 3.0. Obviously this is a potential future hazard associated with advances made in flight deck automation. Usability and pilot understanding or cognition should be a key feature of any future design process with respect to any elements of flight deck automation. The pilot(s) have to be able to see clearly and quickly what the flight deck automation is doing or going to do whilst under autoflight conditions.

5.5.21 Question 3J Responses verses Age Group

Figure 5.52 Question 3J Response verses Age Group

Question 3J addresses the potential effect that automation has on the difference in role between the Captain and First Officer. Once again taking age group three as being relatively insignificant in magnitude it can be seen that all other age groups have moderate to strong disagreement with the suggestion that automation reduces the

difference in role between the Captain and First Officer. From figure 5.39 the overall mean value is -0.9 and the median is -1.5.

5.5.22 Question 3O Responses verses Age Group

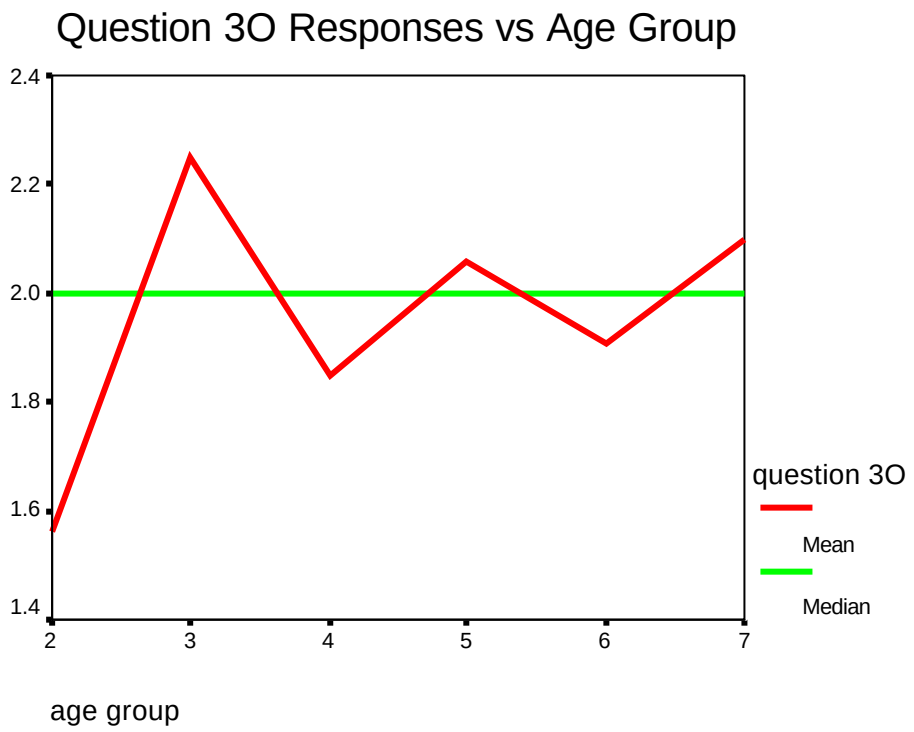

Figure 5.53 Question 3O Response verses Age Group

Question 3O asks the question 'as a result of flight deck automation what is the minimum number of technical crew (pilots) you would expect to be necessary to operate a large passenger aircraft on long distance flights?'. There seemed to be a reasonable consensus that 2 pilots would be the minimum. Although there were a number of responses for 0, 1, 3 and 4 pilots as well. The overall mean value was 1.9 and the median was 2.0.

5.5.23 Summary - Section Three Analysis

In terms of potential hazards associated with future advances made in flight deck automation with respect to human factors, safety and operational procedures issues section three of the questionnaire highlights the following observations:

1. It can be said that the pilots surveyed generally have strong agreement with the concept that future advances in flight deck automation will lead to increased safety.

2. Generally it can be said that there is a moderate to strong disagreement with the proposal that increased reliance on flight deck automation has led to potentially lower levels of safety.

3. There is a general consensus that there will be problems maintaining 'hands on' currency due to future advances in flight deck automation.

4. Thus it can be said that the respondents believe that advances in flight deck automation will lead to 'hands on' currency for pilots being adversely affected however, levels of safety will be increased and not potentially reduced as a result.

5. There is strong agreement that advanced levels of flight deck automation are increasing the amount of useful information available to pilots.

6. There is moderate to strong agreement that future advances in flight deck automation will enhance situational awareness.

7. There is a moderate level of agreement with the suggestions that sometimes the response/behaviour of the aircraft due to the level of flight deck automation surprises me and that some automated functions cause misunderstanding or hesitation by pilots..

8. Only moderate agreement is displayed with the suggestion that some automated functions are straight forward and understood instinctively by pilots.

9. From the questions concerning to the relationship between the human operator (pilot) and the automated functions associated with the modern flight deck there appears to be no overriding opinion either way or just a mainly moderate agreement with the proposals. Quite possibly the human operator (pilot) has been exposed to such a level of flight deck automation for a such a period of time now that it no longer presents such a critical issue to them in general.

10. There is moderate agreement with the suggestion that pilot behaviour and aircraft system knowledge is improving as a result of progress in computer software and technology development.

11. There is moderate disagreement with the suggestion that more memory items are required for pilots of highly automated aircraft as opposed to non-automated aircraft. This response is in line with the general philosophy of highly automated aircraft where most actions and recall items such as engine shutdowns, propeller auto feathering, electrical load shedding etc are done automatically.

12. There is moderate agreement with the suggestion that pilots are less stressed after a day's work in a highly automated cockpit compared to previous generation aircraft.

13. There is very strong agreement with the proposal that stress and fatigue increases rapidly when the flight crew does not fully understand what the flight deck automation is asking the aircraft to do. This is a potential future hazard associated with advances made in flight deck automation. Usability and pilot understanding or cognition should be a key feature of any future design process with respect to any elements of flight deck automation. The pilot(s) have to be able to see clearly and quickly what the flight deck automation is doing or going to do whilst under autoflight conditions.

14. There is moderate to strong disagreement with the suggestion that automation reduces the difference in role between the Captain and First Officer.

15. There seemed to be a reasonable consensus that as a result of advances made in flight deck automation 2 would be the minimum number of technical crew

(pilots) you would expect to be necessary to operate a large passenger aircraft on long distance flights.

5.6 Findings & Conclusions

5.6.1 Section One Findings

In terms of potential hazards associated with future advances made in flight deck automation with respect to manual flying skills section one of the questionnaire highlights the following observations:

Manual flying skills have (and will more than likely continue to) deteriorated through both the advent of autoflight and advances made in flight deck automation.

There is no clear opinion either way that manual flying skills are (or will be) considered secondary to system management through either the advent of autoflight or advances made in flight deck automation.

It cannot be said with any degree of confidence that there will be a decreased level of flying skills required resulting from future levels of flight deck automation.

The pilots surveyed are very receptive of the idea of flying aeroplanes with a high level of automation and hopefully this can be taken as indicative of the industry as a whole.

It seems quite clear that the respondents as a whole agree strongly with the concept that automated cockpits demand more cross-checking between pilots. This should be a cornerstone of any training philosophy on a highly automated aircraft.

5.6.2 Section Two Findings

In terms of potential hazards associated with future advances made in flight deck automation with respect to training issues section two of the questionnaire highlights the following observations:

From the results of the questionnaire the opinion of the industry respondents is such that the level of training required for pilots as a result of advanced levels of flight deck automation has increased.

There can be no possible future benefit gained through decreased levels of training required as a result of future levels of flight deck automation.

It can be seen that the opinion from the industry is that level of education for new entrants is gaining importance even in the older age groups who have generally spent a long time in the industry. Also any dramatic reductions in the flying experience level of new entrants as a result of future levels of flight deck automation are not readily foreseen.

Advances in flight deck automation have led to changes in training methodologies.

There is moderate agreement that the effectiveness of training for procedures which require memorization has improved for highly automated aircraft as opposed to previous methods used in non-automated aircraft.

There is moderate agreement that pilot skills and behaviour cannot always be detected through results of check flight programs.

Pilots do often experience difficulty monitoring or verifying the actions that they have commanded of the flight deck automation during initial training on a new aircraft type.

Pilots do often experience difficulty formatting information so that the flight deck automation will accept and execute their commands during initial training on a new aircraft type.

Pilot workload due to a high level of flight deck automation decreases as the result of a higher level of training in aircraft systems knowledge and characteristics. Generally the workload of the pilot(s) does not increase with a corresponding increase in automation.

5.6.3 Section Three Findings

In terms of potential hazards associated with future advances made in flight deck automation with respect to human factors, safety and operational procedures issues section three of the questionnaire highlights the following observations:

The pilots surveyed generally have strong agreement with the concept that future advances in flight deck automation will lead to increased safety and there is a moderate to strong disagreement with the proposal that increased reliance on flight deck automation has led to potentially lower levels of safety.

There is a general consensus that there will be problems maintaining 'hands on' currency due to future advances in flight deck automation.

Thus it can be said that the respondents believe that advances in flight deck automation will lead to 'hands on' currency for pilots being adversely affected however, levels of safety will be increased and not potentially reduced as a result.

There is strong agreement that advanced levels of flight deck automation are increasing the amount of useful information available to pilots and only moderate agreement that future advances in flight deck automation will enhance situational awareness.

There is a moderate level of agreement with the suggestions that sometimes the response/behaviour of the aircraft due to the level of flight deck automation surprises me and that some automated functions cause misunderstanding or hesitation by pilots.

Only moderate agreement is displayed with the suggestion that some automated functions are straight forward and understood instinctively by pilots.

From the questions concerning to the relationship between the human operator (pilot) and the automated functions associated with the modern flight deck there appears to be no overriding opinion either way or just a mainly moderate agreement with the proposals. Quite possibly the human operator (pilot) has been exposed to such a level of flight deck automation for a such a period of time now that it no longer presents such a critical issue to them in general.

There is moderate agreement with the suggestion that pilot behaviour and aircraft system knowledge is improving as a result of progress in computer software and technology development.

There is moderate disagreement with the suggestion that more memory items are required for pilots of highly automated aircraft as opposed to non-automated aircraft. This response is in line with the general philosophy of highly automated aircraft where most actions and recall items such as engine shutdowns, propeller auto feathering, electrical load shedding etc are done automatically.

There is moderate agreement with the suggestion that pilots are less stressed after a day's work in a highly automated cockpit compared to previous generation aircraft.

There is very strong agreement with the proposal that stress and fatigue increases rapidly when the flight crew does not fully understand what the flight deck automation is asking the aircraft to do. This is a potential future hazard associated with advances made in flight deck automation. Usability and pilot understanding or cognition should be a key feature of any future design process with respect to any elements of flight deck automation. The pilot(s) have to be able to see clearly and quickly what the flight deck automation is doing or going to do whilst under autoflight conditions.

There is moderate to strong disagreement with the suggestion that automation reduces the difference in role between the Captain and First Officer.

There seemed to be a reasonable consensus that as a result of advances made in flight deck automation 2 would be the minimum number of technical crew (pilots) you would expect to be necessary to operate a large passenger aircraft on long distance flights.