CHAPTER SIX:

SUMMARY, DISCUSSIONS AND RECOMMENDATIONS

6.1 INTRODUCTION

This study has focused on the quantitative development of a valid and reliable instrument to measure airline pilots' perceptions of the training climate associated with advanced automated aircraft. The research was conducted using a positivist epistemology. Ultimately, the goal was to construct a questionnaire by operationalizing an unobserved hypothesised construct (perceptions of the advanced automated aircraft training climate) based on three levels of analysis (the microsphere, mesosphere and macrosphere) to conceptualise it. As a secondary purpose, the study sought to explore the relationships between demographic categories and phenomena relating to the data in terms of the latent sub-constructs that emerged from the empirical observation.

A preliminary literature review revealed that, although many airlines have initiated major purchases of advanced aircraft, very little research has thus far been undertaken to determine what the impact of the new technology would be on human behaviour in terms of aviation safety. The fact that human factor issues associated with advanced aircraft training are currently understudied provided the impetus for the present research. In particular, the topic of training pilots to operate technologically advanced aircraft has hitherto been neglected from a psychological and human behavioural perspective.

Global economic pressures have led aircraft manufacturers to turn to computer technology in the hope to create highly efficient and, ultimately more marketable products and services. The cost of this increased efficiency of aircraft in all respects, from surgically precise long-distance navigation to increased fuel economy, has led some observers to warn that human operators are being designed out of the flight deck and, more concerning, being designed out of the knowledge loop in general. The philosophy of current advanced aircraft manufacturers is that the less detail a pilot knows about the modern aircraft, the less likely they are to make mistakes. Overall, the statistics do tell a story of reduced human error, coupled with a reduced air accident rate. Detractors to increased aircraft automation however, continue to argue that the correlation between increased computerisation and reduced aircraft accidents rates, do not necessarily confirm causation, *per se*. These and other such issues in the industry, added to the interest in pursuing the present research study.

Computerisation and technology are a part of everyday life and are here to stay. This is particularly true for the commercial aviation sector. The implementation of technological advances in modern airliners has resulted in many improvements to flight safety, which has never before been possible. Paradoxically, increased computerisation has also introduced brand new human factor issues into the human-machine interface. These issues threaten to compromise the delicate fabric of aviation safety, and continue to profess the old adage that the human being will always be the weakest link in a complex system.

To mitigate adverse effects stemming from the complication arising from highly complex automation systems, research into training for advanced aircraft is increasingly being recognised as a way to reach a compromise between new computer-based aircraft and old human habits. This paradigm begins to challenge the problem at a root level. Because suitable training is a prerequisite for changing behaviour in an unusual workspace such as the flight deck, researchers in the field can add significant value to such specific flight safety initiatives.

The ability of an individual to navigate successfully the labyrinth of learning required to operate a highly advanced aircraft that employs complex automation depends on the person's perceptions of the training climate associated with these aircraft. This study was, in part, motivated by the realisation that only by understanding the psychological perspectives of trainees (which is a core individual level of analysis), whom are engaged in learning to fly advanced aircraft within an airline setting, is it possible to gauge the related phenomena associated with flight deck behaviour. In other words, this study tackled a root cause for pilots' flight deck behaviour (be it appropriate or inappropriate), namely, behaviour as a manifestation of training. The study concluded that, to a large extent, trainees' success in flight training depends on the way they perceive their training environment at three systemic levels (micro, meso and macro).

Neither safety issues nor the considerable financial implications associated with high training failure rates can be overemphasised; therefore it may be important for organisations to evolve training paradigms and methods by introducing appropriate interventions and policies before problems arise. The study focused on scale development, because accurate quantitative measurement of the climate can guide such interventions. Only by understanding empirically the phenomena associated with the psychological and in turn behavioural factors that affect the human-advanced machine interface, can any training intervention be successful in the long term.

As part of promoting an empirical ontological understanding of training for advanced aircraft, this study researched and designed an appropriate measurement instrument in terms of the positivist paradigm. Therefore, the quality of conclusions and recommendations may be regarded as relatively high, based on the stringent scientific method complied with. Data collected for this study can, and should be re-analysed, and findings corroborated or disputed by future researchers interested in the topic, or wanting a deeper understanding of aviation human factors related to technology.

This chapter contains a review of the results and a re-examination or discussion of some of the most crucial findings of this study. In order to completely understand recommendations and suggestions for future research; the study objectives, findings, the aims, assumptions and research methods that were dealt with in the first five chapters are revisited and revised for additional clarity. In addition, some of the implications for airline organisations and possible safety-enhancing recommendations are briefly discussed, based on only the main and significant findings in the study.

6.2 RESEARCH OBJECTIVES

In general, the purpose with this study was to measure the perceptions of airline pilots with regard to the advanced aircraft training climate and to compare and model these perceptions in terms of demographic variables. The study undertook to obtain sufficient empirical data from a representative cross-organisational sample of qualified airline pilots who were engaged in training to operate, or who had trained to operate, highly advanced commercial aircraft that employed very complex automation systems. The study specifically sought to measure the group's perceptions associated with the advanced aircraft training environment or climate, and to determine what constituted the latent structure of a hypothesised construct related to this climate. To follow up on the aforementioned discussion, the study also attempted to identify the underlying characteristic phenomena present in the data set by means of an intentionally thorough, statistical examination of the latent factors that were extracted from the data set. The main reason for this approach was based on an attempt to cover as much of the topic as feasibly possible so as to add to the body of knowledge with new information, and possibly assist future similar research.

The primary objective of the study was to obtain an empirical measurement of the hypothesised construct (see Figure 13) by conceptualising a multi-dimensional questionnaire in order to develop a valid and reliable scale. Secondarily, the research objective was also to explore the statistical nature of the demographic variables of the respondents in terms of the latent factors of the construct.

The following research objectives were generated to guide the study:

- to identify the organisational behaviour attributes applicable to the main research construct by critiquing and discussing the relevant literature, historical data, and current world trends on the topic of interest;
- to develop a hypothesised multivariate psychological systems model (based on empirically grounded theory) from which criteria for the construct *perceptions of the advanced automated aircraft training climate* can be identified and tested in a quantitative study involving a cross-organisational sample of airline pilots from South Africa;

- to generate a tentative pool of scale items based on the hypothetical systems construct;
- to validate the item pool statistically by quantifying the judgements gained from subject matter experts and using Lawshe's (1975) content validity ratio technique;
- to obtain sufficient empirical evidence to determine the nature of the latent factors of the hypothesised construct and to develop an understanding of their relationships to the surface attributes and to each other;
- to use statistical methods to develop a valid and reliable measurement instrument to assess airline pilots' perceptions of the training climate associated with advanced automated aircraft, where the following generic steps were used as a guide for the scale development (DeVellis, 2003; Netemeyer *et al.*, 2003; Pett *et al.*, 2003):
    - develop a hypothesised model of the main research construct;
    - generate appropriate items from the available theory;
    - operationalize the main construct by developing a scale (for instance, using results from an expert questionnaire); and
    - evaluate the robustness of the scale (appropriate statistics to determine validity and reliability);
- to explore the relationship between respondents' demographic variables and the latent factors of the construct;
- to determine what the theorised construct may be for future research (see Figure 60, for an example) based on the mathematical or statistical analyses of a dataset obtained through empirical methods; and
- to make recommendations to airline organisations and other interested parties based on the findings, which emerged only after a thorough or in-depth examination of the empirical dataset.

6.3 RESEARCH METHODOLOGY AND PROCEDURE

The primary objectives of the study were accomplished both from a theoretical perspective (in the form of the literature review) and in terms of practical assessment (the collection of empirical evidence). Defining the main research construct proved challenging, as a multitude of climate constructs were gleaned from the current body of knowledge. In developing the final training climatic construct however, three fundamental aspects were married, namely; first concepts, theories and constructs from education (learning), second, advanced aircraft technology and, third, climate theory. The "training climate" construct was by far the most complex definition to formalise for the study. It was found that a plethora of definitions, research and journal papers exist on the subject. Because most of the information in the literature on the topic deals with "training" and "climate" as separate constructs, determining what constitutes the applicable "training climate" proved challenging.

Adopting the positivist's paradigm, a two-step multiple-method approach was used to validate a set of questionnaire items that operationalized the main research construct and ultimately provided the data to develop a reliable measurement scale. Therefore, two surveys were triangulated within a single ontology.

An expert survey was used to validate the formulation of the original 106 items of the hypothesised construct. Using a convenience sampling method, an expert group in the realm of interest was identified: 17 highly experienced airline flight instructors and university academics participated in the expert validation process. An instrument in the form of a structured questionnaire was developed and subsequently used to elicit judgements from the sample of experts. The content of the opinions from the experts was analysed in detail using the quantitative method developed by Lawshe (1975). The technique was successfully used to determine the extent of the overlap between the items formulated on the basis of the literature study and the domain of the hypothesised research construct.

The construct validation process resulted in a very rigorous elimination of redundant items. The panel of experts could agree on only 42 items of the 106 items initially presented for judgement which they believed adequately covered the topic of interest, and which could then be used in the next phase of scale development. This represented an endorsement rate of 39.62%. Although the endorsement of statements that could potentially define the main hypothesised construct was disappointing, the number of statements retained was sufficiently robust to continue with the research study. This was in accordance with the literature supporting the requirement for a minimum of 40 items in scale development of this nature. The very critical judgement received from the panel of experts resulted in a latent structure of the construct that may be considered very narrow in relative terms. Nonetheless, the final output, using 42 items, resulted in high communalities. Because the method was so stringent in nature, it becomes very difficult to dispute the point that the penultimate explanation of the variability in the construct under study was not derived from a high quality measurement scale.

The final 42-item cohort was packaged in a structured questionnaire and distributed both electronically and manually to the population of interest. However, the web-based electronic questionnaire was used as the main source of empirical data. Both airline management and pilots' unions were extremely helpful in making this study a success by providing the required assistance to elicit participation in the survey. A total of 229 useable returns formed the basis of the final exploration, examination and analyses of the quantitative section of the research.

The data was audited and presented in an appropriate format for analysis. Two statistical packages, namely Statistica Version 7 and SPSS Version 17, were used for the data analysis. The analytical process began with a basic factor analytic exploration, namely a principle axis factoring. This analysis produced a stable three-factor solution. The latent factors that explained most of the variability in the construct were labelled *Organisational Professionalism*, *Intrinsic Motivation*, and *Individual Control of Training Outcomes*. Firstly, the factor called *Organisational Professionalism* was formulated based on items describing both the macro level of analysis (the organisation or airline) and the meso level of analysis (the group or instructor-trainee combination). Secondly, the final two factors (*Intrinsic Motivation* and *Individual Control of Training Outcomes*) were formulated using items that described only an individual (or trainee) level of analysis.

Although the original hypothesised model of the research construct was based on three levels of analysis (the macro, meso, micro levels), interestingly, the final latent structure combined two levels (the macro and meso levels) into one (Factor 1) and split the core level (the micro level) into two factors (Factor 2 and Factor 3), clearly shown in Figure 30. This structure suggests the important role played by the individual in a systemic and dynamic environment, thereby conforming to the seminal premise of organisational behaviour, which starts at the individual level. In other words, actions or behaviour at the micro level permeate the other two levels, thus affecting the system holistically.

6.4 MAIN COMPONENTS OF THE HYPOTHESISED RESEARCH CONSTRUCT

A principal axis factor analysis with an oblique (promax, Kappa-4) rotation was conducted on the data to determine its underlying or latent structure. The main construct is finalised and theorised in Figure 30. In addition, the following main components emerged from this analysis (also see Appendix E):

- Factor 1 – *Organisational Professionalism*:

  This factor essentially relates to the organisational, managerial, bureaucratic and hierarchical aspects of the training climate. Items from both the macro or organisational level (that is, the airline) and intermediate or group level (that is, the instructor-trainees collective) dimensions loaded substantively onto Factor 1 (see Figure 30). Essentially, the factor expresses a component of the theoretical construct relating to the efficiency, effectiveness and professionalism of both the company and its flight instructors. The elements that dominate this factor include organisational co-ordination, structure, trainee support, rules, regulations, sufficient learner feedback and guidance. In terms of the main theorised construct however (see Figure 13, Figure 30 and Table 62), this factor included the domains; Structure (Str), Training Standards (Std), Training Culture (Cu), Training Planning (TPla), Knowledge Environment (En), Communication (Com), Training Conflict (Co), Training Policy (TPol), Intergroup Training Behaviour (InGB), and Power (Pr).

- Factor 2 – *Intrinsic Motivation*:

  This factor contains elements related to the individual or micro level of analysis, the trainee (see Figure 30). The factor predominantly reflects the individual trainee's ability and eagerness to learn and understand complex concepts relating to an advanced aircraft. Learning the aspects of a complex technology is viewed as a structured and iterative quantitative increase in knowledge. The fundamental aspects of this factor relate to an individual's learning approach, preparedness, and willingness to participate and co-operate in training to gain a knowledgeable and working understanding of the advanced aircraft that the person is being trained to fly. In terms of the main theorised construct however (see Figure 13, Figure 30 and Table 62), this factor included the domains; Motivation to Train (Mo), Personality (Per), Training Decision Making (Dm), Training Stress (Sts), and Learning for Technology (Le).

- Factor 3 – *Individual Control of Training Outcomes*:
  The third factor represents the trainee's own perceived level of control regarding their training to operate an advanced automated aircraft, and is measured at an individual level of analysis. Four items found at the micro or individual level (the trainee) loaded meaningfully onto this factor (see Appendix E). The principal elements of Factor 3 relate to the levels of perceived comfort experienced by trainees during training, their belief in their ability to control the outcome(s) of a training session, their capacity to control their levels of stress to perform well, and, ultimately their grasp of the full information load that they are required to cope with in their training. In terms of the main theorised construct however (see Figure 13, Figure 30 and Table 62), this factor included the domains Training Stress (Sts), and Training Decision Making (Dm).

The results of an exploratory factor analysis and item discriminant computation suggest that the final scale produced from the Advanced Aircraft Training Climate Questionnaire (AATC-Q) developed in this study has acceptable psychometric properties and can be confidently used to assess pilots' attitudes or perceptions regarding the advanced automated aircraft training climate for airlines based in South Africa (Appendix C).

It is suggested that airlines and interested parties use the measurement scale to

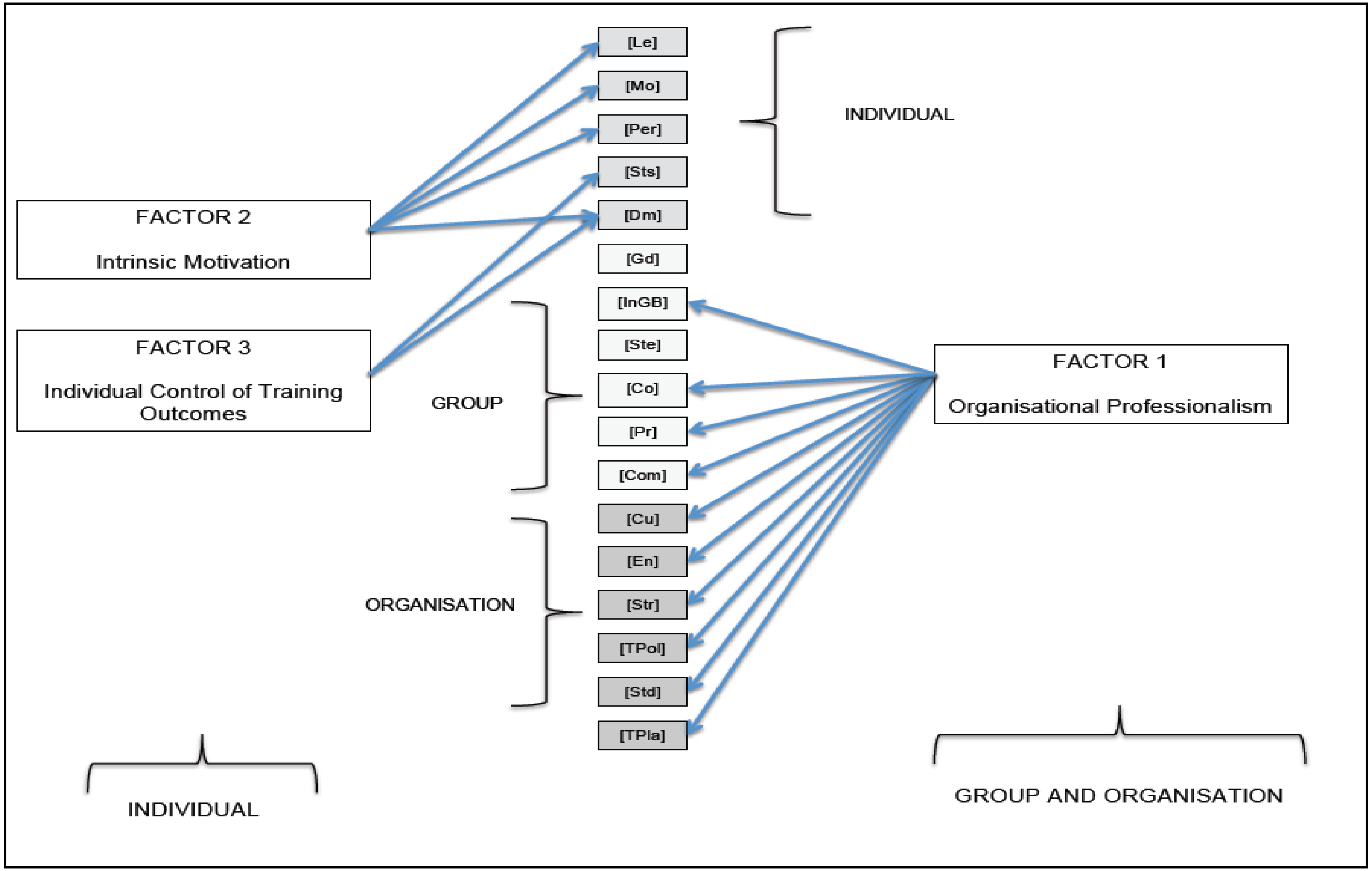
- sensitise airline pilots to their own perceptions with regard to training for technologically advanced aircraft employing highly complex automation systems and how these attitudes can assist or hamper transition training and its long-term success or failure;
- promote communication at three levels of analysis (the individual, group and organisation) in order to improve systemic understanding and thinking, which may ultimately enhance safer and effective flight deck behaviour;
- enhance overall policy changes, which can create an effective and sustainable learning environment for those learning to fly advanced aircraft; and
- assist airline organisations to develop strategies which will improve both aspects preceding training (such as recruitment) and the final training outcome success for advanced aircraft pilots.

The validity and reliability (Cronbach's $\alpha > 0.75$) of the derived behavioural scales (Organisational Professionalism, Intrinsic Motivation, Individual Control of Training Outcomes) were shown to exceed the recommended criteria. These results allowed the study to progress to the next stage, where analyses based on comparative and associational designs were conducted. Finally, more advanced mathematical modelling, based on a stepwise logistic regression computation, was conducted to enhance understanding of phenomena noted in the data, and to interpret the main and secondary findings.

Table 62: Relationship between construct domains and derived scales

Item	Scale Statement	Construct Domain
Q29	Training on this aircraft is well organised.	Structure (Str)
Q27	Training on this aircraft is professional.	Training Standards (Std)
Q23	My company's training produces world class pilots.	Training Culture (Cu)
Q24	Training at my airline is in line with company goals.	Training Planning (TPla)
Q38	The airline is very supportive of its pilots' learning requirements for this aircraft.	Training Culture (Cu)
Q34	There is sufficient training guidance from the company.	Knowledge Environment (En)
Q28	Management follows the rules and regulations appropriately.	Training Standards (Std)
Q39	My company's culture supports training for new technology aircraft.	Training Culture (Cu)
Q30	I understand what the company expects of me when training.	Communication (Com)
Q26	My company has talented people in training.	Knowledge Environment (En)
Q33	If I had to experience a problem in training, it's easy for me to appeal.	Training Conflict (Co)
Q25	I know what my company's training goals are.	Knowledge Environment (En)
Q31	Training at my airline produces safe pilots.	Training Policy (TPol)
Q40	There is sufficient feedback about my training on this aircraft.	Communication (Com)
Q42	My company uses only current training material.	Training Standards (Std)
Q41	Training is in line with civil aviation regulations.	Training Standards (Std)
Q32	The airline gives its pilots an appropriate amount of preparation work for training.	Training Planning (TPla)
Q45	My instructor is willing to listen.	Intergroup Training Behaviour (InGB)
Q50	Pilots are in direct control of the training outcome.	Power (Pr)
Q36	I'm given sufficient time to prepare for training on this aircraft.	Training Planning (TPla)
Q61	It's a good idea to know more than what is required.	Motivation to Train (Mo)
Q52	I try never to be late for a training session.	Personality (Per)
Q53	I co-operate when training in a simulator.	Personality (Per)
Q62	I aim to gain a deeper understanding of this aircraft.	Training Decision Making (Dm)
Q51	Preparation improves performance.	Training Stress (Sts)
Q60	I read to understand so as to gain a deeper understanding of this aircraft's systems.	Learning for Technology (Le)
Q55	I have a positive relationship with my colleagues.	Personality (Per)
Q44	I operate well as a crew member in the simulator.	Training Decision Making (Dm)
Q58	I enjoy studying the technical aspects of the aircraft.	Motivation to Train (Mo)
Q63	I'm comfortable undergoing training for this aircraft.	Training Stress (Sts)
Q57	I'm in control of the outcome of a training session.	Training Decision Making (Dm)
Q64	I can control my anxiety so as to perform well in training.	Training Stress (Sts)
Q49	The instructors on this aircraft don't overload us with information.	Training Stress (Sts)

Figure 30: Final theorised construct based on the empirical dataset



6.5 MANAGERIAL IMPLICATIONS OF THE RELATIONSHIPS BETWEEN DEMOGRAPHICAL AND OUTCOME VARIABLES

The study was conducted strictly within the quantitative, positivist paradigm. Therefore, the findings are based on empirical evidence and the conclusions are statistically supported by a p-value and associated effect size wherever necessary. Although the p-values of many of the findings were significant, the effect size in terms of Cohen's (1988) criterion was found to be relatively mediocre, possibly because the sampling frame was somewhat skewed and relatively small. Nonetheless, robust non-parametric statistical methods were adopted in the data examination to support and validate the conclusions that follow. The final analyses were thus regarded as useful and informative from a managerial and research perspective.

The study has enabled a deeper understanding of the underlying phenomena present within the current dataset, thereby also fulfilling the secondary research objective. Significant theoretical contributions to the current understanding of the topic were provided on the basis of following an in-depth analytical design. For instance, the Kruskal-Wallis test was conducted to compare multivariate data. In addition, where significant differences were found, *post hoc* non-parametric Mann-Whitney tests were used to determine the statistical significance of the actual difference between the highest and lowest ranked categories. Where the order of the independent categories was thought to be meaningful, the Jonckheere-Terpstra (J-T) test was used to assess the possibility of data trends. Furthermore, to assess the relationship between or the extent to which variables may be related and to determine their magnitude and subsequent direction, a correlational analysis was conducted. Kendall's tau-b was used for this measure of association. In addition, more advanced statistics were used to gain a deeper understanding of the dataset. For example, to examine the main and interactional effects of partially independent categorical variables on multiple dependent variables, a non-parametric MANOVA was computed (Pillai-Bartlett trace). Finally, a predictive model of the dataset was developed, based on a stepwise logistic regression. The main theorised construct could therefore be regarded as having attained high content, construct, and predictive validity.

The discussion below is based on the results of statistical analyses. The section is divided according to important demographic findings.

- ***Flight deck position***

  Although airline pilots can hold various positions in the organisation; to make further calculations easier, the pilots were initially captured as predominantly belonging to one of two main categories – either captain (commander of the aircraft) or co-pilot (second-in-command on the aircraft). These two main categories could then be sub-divided further into pilots who operated mainly long-range flights (flights more than six hours long) and those who operated only short-range flights. This sub-division provided an opportunity to analyse four significant demographic classes of airline pilots found in the dataset.

  A non-parametric comparison of the subgroups for the pilots' flight deck position showed that only the behavioural scale *Individual Control of Training Outcomes* was statistically ($p < 0.05$) affected by one of the four flight deck positions (captain long-range, captain short-range, co-pilot long-range, co-pilot short-range). The *post hoc* Mann-Whitney test showed that the short-range captains' scores were statistically higher than those of their long-range counterparts ($p = 0.001$). One possible reason for this difference may be based on the fact that short-range pilots have the opportunity to fly more sectors than long-range pilots do, which implies increased exposure to the technology for the short-range pilots. These findings corroborate an earlier study (Naidoo, 2008), which clearly showed that long-range captains (commanders) had a statistically significant lower perception of advanced aircraft automation in general, when compared to captains who operated the short-range advanced aircraft. However, such a phenomenon may be temporary, and isolated to the specific sample frame. Over time, short-range captains would become the new long-range captains, as they move up the seniority ranks. It can therefore be concluded that the results obtained from the present dataset, is due in part to the fact that the current generation of long-range captains within the present sample frame have high experience levels in analogue type aircraft. Experience levels in traditionally analogue type aircraft are expected to dissolve over time as airlines begin acquiring more efficient advanced digital aircraft. It would be a recommendation that the theorised construct developed for this study be re-examined in years to come, when it is expected that very few pilots would have any exposure to traditional analogue type aircraft.

In terms of the present study's findings, low perceptions of individual control of training outcomes may be enhanced if a pilot has opportunities to operate the aircraft in question more frequently. This is in accordance with Fishbein and Ajzen's (2001) proposal that familiarity or frequent exposure can enhance perception positively. It is therefore recommended that long-range captains who are not very experienced on particular types of aircraft or who have very little advanced aircraft experience, be given flight opportunities on shorter sectors. Possibly, these pilots should be rostered (planned/scheduled) to fly more often on domestic and regional flight sectors during the early phases of operation after their qualification on an aircraft. This will boost their personal confidence in operating the new advanced aircraft through exposure, and significantly improve their perceptions of control, resulting in safer and more competent pilots. In the long-term however, such intervention would not be necessary as all new long-range captains are then sourced from the short-range advanced aircraft pool.

- ***Size of the organisation***

  In order to compare different sizes of airlines found within the dataset, three categories were created to make an initial computation easier. Airline organisations were classified into one of three main groupings, depending on the number of aircraft the organisation operates and the number of employees working for the enterprise. Pitfield, *et al.,* (2010) describe carrier sizes in terms of the number of aircraft carrying more than 99 passengers in an operating fleet. The size of the organisation used for the present study was then categorised as small, medium or large (defined in Section 4.11). It was found that two behavioural scales were significantly affected by the size of the carrier demographic, namely *Organisational Professionalism* and *Intrinsic Motivation* ($p < 0.05$). However, *post hoc* testing showed that only perceptions of the behavioural scale *Organisational Professionalism* were significantly affected by whether a carrier was regarded as a relatively larger operator or as a relatively smaller operator. It was noteworthy that the pilots employed by the operators classified as "larger", scored statistically significantly higher (with a medium effect size) on the *Organisational Professionalism* behavioural scale.

A possible reason for this observed phenomenon may be, that when employees find it easier to familiarise themselves with management and instructors, as in the case of smaller companies, they tend to have lower perceptions of the level of professionalism offered. In addition, larger companies also have access to more budget and therefore greater resources, creating a sense of professionalism. To maintain control over a large corporation it is possible that complex levels of bureaucracy evolve within the enterprise in a false hope in stemming resource haemorrhaging (Drucker, 1946), these bureaucracies may in turn add to a false perception of organisational professionalism for the individual. Alternatively, and more likely; when one compares the larger airline organisations in South Africa (South African Airways and British Airways Comair) to the smaller operators, it is noticed that the two larger companies utilise and maintain their own flight simulator centres. Pilots employed at the larger operators therefore undergo flight simulator training twice a year, as opposed to the smaller operators' pilots who undergo flight simulator training only once a year. This difference may add to the higher levels of organisational professionalism perceived by the trainees of the larger operators.

It is recommended that the flight instructors and management in charge of training structure and policy at carriers with low scores on the *Organisational Professionalism* scale make an effort to communicate with trainees regularly and in a more structured, or formalised way. Training centres should be well equipped with the resources needed to enhance learning (such as training footprints, programmes, timetables, audio and visual media, and full time clerical staff). In addition, smaller airline operators of advanced aircraft should endeavour to send their pilots for flight simulator training at least twice a year (every 6 months) as opposed to the mandatory once a year requirement currently practiced.

Clearing up ambiguity and misunderstanding early on in a candidate's training experience by opening up communication channels, can also influence trainees' perceptions of organisational professionalism, and ultimately catalyse successful outcomes, not only for the individual, but also for the organisation systemically.

- ***Computer literacy***

It was important to understand and examine the effects of participants' perceived levels of computer literacy on their perceptions of the advanced aircraft training climate, because computer science is regarded as the cornerstone of modern technology.

A Jonckheere-Terpstra test suggested that the order of computer literacy – poor, average, above average or excellent – was statistically significant. Only the two behavioural scales at the individual level of analysis were affected by this demographic: *Intrinsic Motivation* and *Individual Control of Training Outcomes* (J-T[4] = 10178.50, 10888.0; Std. J-T[4] = 2.948, 4.272; $p < 0.01$). These results provided evidence which attests to the phenomenon that, as pilots' perceived levels of computer literacy increase or improve, so too does their motivation to learn about new technology aircraft and personal feelings about their ability to control outcomes related to training for advanced aircraft. The third latent construct, *Individual Control of Training Outcomes*, was significantly correlated with pilots' perceptions of their computer literacy (τ_s = 0.216, $p < 0.001$, small effect). This result indicated that, as pilots begin to believe that their levels of computer literacy improve, so too do their perceptions of their ability to be in control of, and take charge of their learning to operate advanced aircraft types.

It is recommended that airlines recruiting pilots to operate technologically advanced aircraft, should possibly consider a candidate's computer science background at either the secondary school or tertiary education levels. Candidates with such computer science backgrounds are likely to adjust more easily to the technical aspects of the advanced aircraft. It is also recommended that recruitment specialists at airlines be more cognisant of technologically averse candidates when hiring for the advanced aircraft fleets. Such candidates are likely to struggle through their conversions onto advanced aircraft employing complex automation. Subsequently, technologically averse pilots may become a safety issue (from a human factor perspective) on the actual aircraft engaged in line operations.

- ***Effect of Digital flight experience*Computer literacy interaction on perceptions***

  Perhaps one of the more important findings in this study was that there was a significant influence from the interacting effect between subjects' levels of experience in advanced aircraft on the one hand and their perceived levels of computer literacy on the other, as opposed to the influence of the variables "experience" and "computer literacy" in isolation. It was noteworthy that the behavioural scale *Individual Control of Training Outcomes* was significantly affected by this interaction and that this in turn had an impact on respondents' perceptions of the advanced aircraft training climate in terms of the logistic sigmoid or s-curve.

  After an examination of the data, it was found that the mean rank scores on the *Individual Control of Training Outcomes* (Factor 3) behavioural scale were significantly different for pilots who reported low experience in advanced aircraft, combined with a high level of computer literacy (Mean Rank = 82.48), when compared to the scores of pilots who reported high experience in advanced aircraft, combined with a low level of computer literacy (Mean Rank = 58.72). The effect of this difference in scores was regarded as medium ($U=1585.5$, $p < 0.001$; $r = 0.30$).

  This finding reveals that, even though a subject may have very little experience on advanced aircraft, if the person has some computer science background (possibly at secondary school or university level), the candidate's lack of experience can be offset by high computer literacy levels, which in turn increase or improve personal control in training success. The ability to grasp abstract computer science concepts at a secondary school or tertiary education level (computer literate) is a definite indication of a candidate's ability to grasp technical and abstract advanced aircraft issues. As aircraft become more technologically advanced, such skills, knowledge and related attitude may become increasingly important in new recruits, because it would be a difficult if not an impossible task for any airline training section to cover every aspect or scenario associated with the technicalities of a new aircraft. Therefore, high levels of aircraft experience would not guarantee ease of training for a trainee who is computer illiterate. The inherent motivation of a candidate, as a spin-off from the interaction effect, can make the difference between highly knowledgeable and less knowledgeable pilots. An individual effort and personal responsibility of ground school studies are vital for a trainee of an advanced aircraft to succeed.

This conclusion and recommendation is regarded as important for airlines, particularly when recruiting new hire pilots for advanced aircraft training. Ensuring that candidates with the optimal combination of flying experience and computer literacy are employed may promote successful training outcomes. The effect of the interaction between levels of experience and perceived computer literacy was scrutinised in depth in Sections 5.9.4 and 5.10, using both multivariate techniques and logistic regression.

- ***Pilots' initial training***

  Traditionally, airlines have endeavoured to recruit military-trained pilots. The logic behind this method was that it could ensure safety within flight operations from a highly structured environment based on rules, regulations and standardised operating procedures. Therefore, it was hoped that military trained recruits would have developed advanced regimental skills from exposure to the military, in turn becoming ideal candidates for employment within such a highly structured organisation. The results from this study show that there may have been some merit in this preference, as a statistically significant difference was found between the perception scores of those pilots who had been trained in the military (in a highly structured, regimented environment [Mean Rank = 127.39]) and those of pilots who had no military background (Mean Rank = 106.57) with regard to their views of *Organisational Professionalism* (U =

4828.5, $p < 0.05$). However, these results should also be taken in context, in that the majority of military-trained airline pilots are also employed at the larger carriers (South African Airways and British Airways Comair).

Nonetheless, a regimented (that is, military) or otherwise highly structured initial flight training background can influence the overall perceptions of the advanced aircraft training climate for subjects who are making the transition to advanced aircraft. Pilots who are training for these types of aircraft may be required to adapt their knowledge of, or past experiences with, a structured learning environment to facilitate their acquisition of technically complex information. On the basis of this finding, it is recommended that airlines ensure that new candidates are provided with precise or detailed training plans prior to commencing their training for advanced aircraft. Such a structured approach to training for advanced aircraft can enhance organisational perceptions of the learning environment and thus result in more successful training outcomes.

- ***Predictive model***

  To obtain a predictive model based on the empirical data, a backward stepwise logistic regression analysis was completed. After five steps, a model containing four predictors subsequently emerged. The process resulted in the identification of four demographic variables that successfully predicted a subject's perception of the *favourability* associated with the advanced aircraft training climate. The overall percentage of cases for which the dependent variable was correctly predicted by the model was 63.8%.

In the final model, the dependent variable *positive climate favourability* was calculated on the logit scale. The computation results then showed that the probability that a respondent would perceive the advanced aircraft training climate as favourable could be expressed with the following logistic regression equation:

Logit = ln (p/1-p) = -2.603 + 0.63 * (interaction effect) – 1.064 * (advanced aircraft experience) + 0.485 * (route training) + 0.806 * (simulator training).

The logistic equation was an important result from the data exploration, as it provided evidence that, if an airline organisation knows a candidate's score on the interaction effect between the candidate's level of experience and his or her perceived level of computer literacy, his or her actual experience in advanced aircraft and his or her preferences for route and simulator training, the organisation can effectively predict the state of the training climate (level of favourability).

Alternatively, it can be deduced that the advanced automated aircraft training climate comprises the components, computer literacy*advanced aircraft experience interaction, route training preference, and simulator training preference. These four categories of demographics have emerged as important variables within the dataset. Hence, it is recommended that airlines make an effort to gain an understanding of these variables for their candidates when assessing the organisation's advanced aircraft training climate. Addressing any shortcomings associated with these demographic variables will enhance training plans, policies and structures, thereby strengthening the probability of a successful training outcome.

- ***Findings at the organisational behaviour levels of analysis***

  At both a macro level or organisational level, and an intermediate or group level of analysis, an examination of the results suggests that it is imperative that management and flight instructors provide trainees with sufficient feedback and timeous learning plans. Therefore, the results highlight the point that communication can play a vital role in the advanced aircraft training climate. Effective communication based on effective feedback loops appears to be essential for creating a sustainable and favourable advanced aircraft training climate. Management should therefore explore various communication methods, such as electronic versus paper-based communication. Conversely, sufficient feedback should be encouraged from learners so that those who have the authority and power to do so have an opportunity to implement timeous changes or to enhance the training policy, procedure and structures systemically.

At a micro level or individual level of analysis, the data clearly shows that the latent structure of the main construct under examination consisted of two factors of importance based on the trainee. This provides sufficient evidence that the trainee is the cornerstone of the training initiative. Every individual pilot is therefore responsible for both the control over, and final success, of an advanced aircraft training event. Management and flight instructors should provide sufficient support in the form of learning and study skill-sets to trainees who appear to be having problems. Instructors of advanced aircraft should therefore be extremely good empathisers with an acute ability to understand others' stressors.

It is more than likely that candidates who are undergoing advanced aircraft transition training who are not technologically averse, and who end up being unsuccessful; simply do not have, or are not aware of, the tools available to them to facilitate their learning. In these cases, one-on-one instructor-trainee input is required in order to strengthen the micro-level and thus enhance the training climate as perceived by that individual.

6.6 LIMITATIONS OF THE STUDY

In general, the results suggest that the behavioural measures of *Organisational Professionalism*, *Intrinsic Motivation* and *Individual Control of Training Outcomes* are sufficiently reliable and valid to capture the perceived training climate associated with advanced aircraft that employ highly complex automation. Some additional elements that influence overall perceptions may relate to the type of organisation and the leadership style associated with it at both the managerial and instructional levels. Researchers should therefore endeavour to select appropriate measures that incorporate elements that are relevant to specific contexts, and be cautious in generalising the results of the AATC-Q across international contexts. A cross-national comparison and validation using this measurement instrument could solve some of the problems related to the context-sensitivity of the three scales. In addition, any additional examination of phenomena associated with demographics, requires a thorough definition of demographic categories.

One limitation in this study arises from the use of a highly comprehensive and structured questionnaire in both the initial construct validation and the large sample survey. Each questionnaire also consisted of a detailed preamble, requiring a specific level of understanding by the participant. Although the final questionnaire eventually consisted of fewer than a hundred questions, it still took approximately 30 minutes to complete. This could have influenced respondents' willingness to participate.

Another limitation concerned the interpretation of the questionnaire, since some candidates may have felt that the survey was connected with the management of their company. At some organisations, pockets of pilots were suspicious of management's intentions and were therefore, understandably very reluctant to participate in the study (even though such suspicion was unfounded). These splinter groups within the population may have caused an increase in response-based bias (where participants who completed the survey were more likely to answer questions in a particular way in an effort to please the researchers), and reduced the overall response-rate.

Although items to develop the scale were thoroughly researched and were based on previous studies of a similar nature in psychology, better items could arguably be selected, validated and found reliable in such measurement construction. Retention of several unidentifiable inferior items may be the reason why the distribution of scores of the factors was not normal and did not yield significant results. This is also reflected in the low practical significance values (effect sizes) found throughout the study.

6.7 RECOMMENDATIONS FOR FUTURE RESEARCH

The following recommendations are made on the basis of the findings:

- Perhaps the more disappointing aspect of this research project was the relatively low level of endorsement of items presented to the subject matter experts for content validation. Future research may be needed to redefine the operational nature of hypothesised construct. The universe of possible content that may operationalize the research construct is limitless, based on the depth and breadth of literature reviewed, therefore better item statements may be used for construct content validation. Nonetheless, the final operationalization of the hypothesised construct and empirical data used in the present research was adequate in constructing a main theoretical construct, for understanding the related phenomena, developing a valid scale and predictive model, and in turn adding new knowledge to the current understanding of training for advanced automated aircraft.

- Out of the over thirty demographic variables used in this study, only a few emerged as significantly and practically relevant to the differences between the various categories or groups regarding perceptions of the advanced aircraft training climate, these were:
  - a candidate's score on the interaction effect between his or her experience level and perceived level of computer literacy,
  - a candidate's actual experience in advanced aircraft,
  - a pilot's preference for route training,
  - a pilot's preference for simulator training,
  - size of the carrier,
  - flight deck position,
  - candidate's level of computer literacy,
  - pilot's initial training.

  Future studies could explore the effect of variables not yet considered in this study, such as a trainee's preferred learning style.

- Behaviour on the flight deck is still influenced by the ability developed by a pilot's Crew Resource Management (CRM) skill. All the airline pilots in the sample frame indicated that they had undertaken a formal CRM course. This may or may not have had an impact on the perception scales developed; however, the relevant literature presents sufficient evidence to suggest that CRM plays a role in enhancing flight safety. It is therefore recommended that future research also focus on the link between CRM and perceptions of the advanced aircraft training climate. Perhaps a new generation of CRM is required for technologically advanced aircraft. The management of resources, not only at a human level, but also at a machine (computer) level, is now a requirement. Present-day CRM targets the human-human interface, but so far, very few tools are provided to pilots to deal with the human-advanced machine interface.

- It would be of particular interest to validate the AATC-Q for internationally operated airlines based in other countries. Findings in this regard could provide the data necessary to produce a generic scale that takes nationality variables into consideration and could therefore also produce a different latent structure of the construct under investigation.

- Future research could use structural equation modelling methods to determine the validity of the three-factor model of the AATC-Q. Exploratory factor analysis, as used in this study, has its limitations in determining structural validity. Therefore, a structural equation modelling method may enable a researcher to postulate relationships between the observed measures and the latent factors *a priori*. The *a priori* relationship between the latent structure and observed variables should then be evaluated statistically to determine the goodness-of-fit with the empirical evidence. The findings could refute or verify the quality of the scale developed in this thesis and therefore provide more information to researchers in the field of aviation psychology, potentially enhancing flight safety from a human factors perspective.

- Additional research is definitely required with regard to the interface between human factors and technologically superior aircraft, both in commercial and general aviation. Longitudinal studies could provide valuable input and add to the current body of knowledge in aircraft automation issues. These studies could also be used to make adjustments to, or complete changes in, airline training philosophies.

6.8 CONCLUDING REMARKS

The application of advanced statistical procedures in this study was made possible by the various excellent commercially available computer software packages. This has allowed the thesis to examine thoroughly the validity of the multidimensionality of the hypothesised construct related to the perceptions of the climate associated with advanced aircraft training. Studies using such procedures and the results from the present study should be considered as only the beginning of the process of unravelling the complex aviation human factor issues associated with modern technologically advanced aircraft using precise measurement tools. The research has provided a logical positivist understanding of training for advanced aircraft and related phenomena. It is hoped that airline organisations, aviation psychologists and other interested parties will use the information set out in this thesis to enhance flight safety systemically – from initial recruitment to the final operational behaviour of the pilot on the flight deck. The findings of, and discussion in this thesis confirm that we have only scratched the surface of the human-advanced aircraft dynamic. It is likely that serious incidents and aircraft accidents associated with the interface between technology and human beings will continue to occur as systems become more and more complex.

Education and training in the appropriate use of such technology are the most logical ways available to airlines to combat the potentially adverse impact of human behaviour on the flight deck, reduce error and in turn reduce accident/incident rates. It is therefore vital that the industry (from regulators, to schools and associations, to enterprises) make a concerted effort to address the ways in which aviators in general, and airline pilots in particular, interact with each other and their technologically advanced machines in a more proactive, rather than in a reactive manner, to ensure their own safety, and that of their passengers, the cargo and the intricate and expensive machines that they fly.