Analysis of the Flight Management Attitudes and Safety Survey

by

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A thesis Submitted in Partial Fulfillment of the Requirements for the Degree of Masters of Science in Applied Psychology

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Abstract

Analysis of the Flight Management Attitudes and Safety Survey by Bernadette Gatien, October 2004.

The Flight Management Attitudes and Safety Survey (FMASS) (Sexton, Helmreich, Wilhelm & Merritt, 2001) is one of the most widely used measures of pilot safety attitudes in research and applied settings. Previous research has shown that earlier versions of the FMASS, (CMAQ and FMAQ) are reliable and valid measures of flight management attitudes. However there does not appear to be any independent research conducted on the psychometric properties of the FMASS. The current study assessed the reliability and validity of the FMASS. Confirmatory factor analysis (CFA) was performed on the FMASS, using data from a sample of Canadian airline pilots. Results indicated the data were not able to confirm the proposed factor structure. In addition, results showed poor internal consistency. The results of the current study indicated that more research is needed on the psychometric properties.

Analysis of the Flight Management and Safety Survey

Human factors play a significant role in safety of employees in various high reliability occupations and industries including nuclear power, offshore oil and aviation (Yule, 2003). High reliability occupations are defined as those, which operate in extremely dangerous and high-risk environments with consistent safe performance (Roberts, 1993). The study of human factors has been instrumental in developing our understanding of human error as a causal factor in organizational disasters, accidents, as well as injury and illness rates. There are various different factors that contribute to accidents such as job characteristics (e.g. physical workload), equipment, work environment, and personal characteristics (Wickens, Gordon & Liu, 1998). Personal characteristics include aspects that are physical and psychological. One specific psychological characteristic that is studied and researched in relation to human error and accidents is attitudes towards safety (Wickens, Gordon & Liu, 1998).

Research on attitudes towards flight management safety has contributed greatly to our understanding of how and why aviation accidents occur. One way that attitudes towards flight safety are studied is via questionnaires or surveys. The most commonly used measure of flight safety attitudes is the Flight Management Attitudes Questionnaire (FMAQ) (Helmreich & Merritt, 1998) and its variants. The Flight Management Attitudes and Safety Survey (FMASS) (Sexton, Wilhelm, Helmreich, Merritt, & Klinect, 2001) is one of the newest versions of the FMAQ and is currently used in the industry as an attitude assessment and training evaluation tool. Previous research on the development and psychometric properties of the FMASS is limited and as such, the purpose of the current study is to examine the reliability and validity of the measure. In order to fully understand how attitudes are related to flight aviation safety some background information on aviation safety, accidents and the evolution of the study of human error and attitudes is provided.

Aviation Safety

During the late 1970's, researchers at National Aeronautics and Space Administration (NASA) began to investigate the exact nature of accidents within aviation. In the United States the National Transportation Safety Board (NTSB) followed NASA's lead and started investigating the human error played in all aviation accidents. Investigators examined how pilot behaviour within the cockpit was related to the number of aviation accidents. Until that time, the focus on improving flight safety was on technical aspects of flight such as working with equipment and improving technical skills. Investigators from NASA's Ames Research Center stepped away from the traditional process of looking at the human and interface design problems and began to investigate the behavioural interactions between pilots (Helmreich & Foushee, 1993). Information on pilot behaviour within the cockpit was gathered using a structured interview developed by Billings, Lauber, and Cooper (Helmreich & Foushee, 1993). The interview was designed to gather specific information from pilots about how crews operated and the types of errors pilots made (Helmreich & Foushee, 1993). During this time, a different group of researchers were investigating the causes of flight accidents that occurred between 1968 and 1976. They found that pilot error was primarily the result of breakdowns in two specific areas, team communication and coordination (Helmreich &

Foushee, 1993). Specifically, problems also arose in areas such as workload management, task delegation, situation awareness, leadership, using available resources including crewmembers and the use of manuals. A number of problems related to the building and maintenance of effective team relationships also became apparent (Helmreich & Foushee, 1993). Break downs in these areas lead researchers to investigate the non-technical skills required as part of safe flight management.

Non-technical Skills

Non-technical skills refer to proficiency in critical thinking and interpersonal relationships, which are not directly related to the mechanical or technical aspects of flight. Non-technical skills include communication, teamwork and decision-making, interpersonal communication, situational awareness, leadership, decision making, and stress recognition (Helmreich & Foushee, 1993). Non-technical skills are key elements in maintaining a high level of safety within aviation. Effective communication is one of the most critical non-technical skills and serves at least five safety critical functions (Kanki & Palmer, 1993). Communication provides information, maintains attention to task monitoring, operates as a management tool, establishes predictable behaviour patterns and establishes personal relationships (Kanki & Palmer, 1993). Poor communication behaviours in and out of the cockpit cause problems by creating confusion and misunderstandings, a lack of attention to the current situation, a lack of leadership and direction, opportunities for unpredictable behaviour patterns and interpersonal strain between the parties involved (Kanki & Palmer, 1993).

In 1997, a near miss incident occurred where a pilot radioed his current position, plan for approach and landing destination in to air traffic control, and noticed moments later another plane on the same flight path. The pilot of the second plane came over the radio and immediately accused the first pilot of not following procedures. The argument escalated to the point where the owner of the airport was forced to interrupt and take control of the situation (Salven, 2002). This is a good example of improper communication behaviours (screaming and name calling) creating interpersonal strain between pilots and ultimately, aggravating a dangerous situation (Salven, 2002). Proper communication behaviours from both pilots could have minimized the length of time it took to resolve the situation.

Proper decision-making is also considered a crucial aspect of flight safety. Poor decision-making appears to have caused a considerable number of military and civilian aviation accidents (Diehl, 1991, as cited in Orasanu, 1993). Decision-making within the cockpit is a process that involves careful consideration in three specific areas: assessment of the current and future situation, risk assessment, and deciding among options (Orasanu, 1993). Often times crews are faced with dangerous or high risk situations and are forced to handle various situational factors that influence the decision making process. Effective decision-making on behalf of flight crews requires a combination of factors including: situational and self-awareness, careful planning, having a collective understanding of the current situation, and using all available resources (Orasanu, 1993). Proper decision-making within the cockpit is influenced by a number of factors, such as familiarity with the current problem or situation, urgency of the situation, and how well the problem is defined (Orasanu, 1993).

A considerable amount of research exists on the process of decision-making and the different types of decisions (Orasanu 1993). However, more information is needed on the types of knowledge, skills and abilities required to meet the demands of decision-making within the cockpit. Furthermore, more defined and standardised performance criteria for evaluation purposes must be developed. The fact that there is a lack of research and knowledge in the area suggests that there may be pilots who possibly lack the proper skills, abilities, and most importantly, the right attitudes that result in appropriate making good flight management decisions.

Accidents and Non-technical Skills

It is important to explain how non-technical skills are related to accidents and how skills in non-technical areas such as leadership, communication, stress recognition, situation awareness are critical to flight safety. The best way to do this is through examples of accidents in which non-technical skills played in a critical role in the saving or fatality of flight crew and passengers. The crash of United Airlines flight 232 in Sioux City, Iowa is one of the most discussed aviation accidents because it is a textbook case where effective non-technical skills in communication, leadership and teamwork contributed to the survival of 111 of its 296 passengers and crew.

While enroute to Chicago an engine malfunctioned causing a complete breakdown of the aircrafts hydraulic system leaving the pilots with little steering ability. Even though there were previous occurrences of aircrafts losing their hydraulic systems, no emergency checklists were available for the pilots leaving them to handle the situation using what resources were available to them. Effective communication, teamwork and leadership between the pilots and air traffic control, flight attendants and passengers, allowed for a clear plan of action and control over the situation. A quick response, clear communication and a calm air traffic control officer communication enabled air traffic control to clear a runway, and provide the pilots with the information they needed in order to find a safe place to land the plane and alert the necessary medical personnel. Effective communication allowed the flight attendants to properly prepare passengers including over 30 children for the emergency landing (Haynes, 1991). Furthermore, open communication between crew and passengers lead to the critical discovery that one of the passengers was a pilot with a considerable number of flying hours on the exact aircraft they were on, and was capable of assisting the cockpit crew in controlling the aircraft. The teamwork between the pilots and assisting passenger allowed the cockpit crew to maintain some control in what appeared to be uncontrollable situation. Despite a complete lack of emergency protocol the pilots and crew were able to land the aircraft without total loss of life. Without the proper non-technical skills and attitudes towards communication, leadership and teamwork, investigators felt that there would have a greater loss of life (Kilroy, 2004).

In 1972, an Eastern Airlines crew flew their aircraft into the ground of the Florida Everglades. The crash was the direct result of their preoccupation with a malfunctioning landing gear indicator (Kayten, 1993). All three crewmembers focused their attention on the malfunctioning indicator light and paid no attention to their position or proximity to the ground. While the National Transportation Safety Board noted that the entire crew was preoccupied with the failing indicator light, the report highlighted that it was captain who failed to ensure that one of the pilots was maintaining the proper position of the aircraft (Kayten, 1993). These accidents and many others clearly demonstrate how proper non-technical skills can lead to positive or disastrous results in an emergency situation.

Non-Technical Skills and Training

During the early 1970's, the training individuals received was thought to be insufficient and did not provide the necessary knowledge and skills to ensure proper flight deck management. Consequently, crew training content was dissected and examined for flaws or gaps, thought to be related to the incidence of human error. A number of changes to training programs were made, including the incorporation of "Crew Concept Training" (Helmreich & Foushee, 1993, p 7), which included simulator exercises and revisions to flight manuals. Despite these changes and small improvements in cockpit performance, crews received little instruction and guidance on how to perform as a team (Helmreich & Foushee, 1993). This prompted the aviation industry to gather and discuss recent research findings and concerns in the context of the current and ongoing trend in human error. It became evident from the meeting that industry experts still had serious concerns regarding the human element of aviation accidents despite a number of advances in technology and changes made to training programs (Helmreich & Foushee, 1993). Researchers and industry experts immediately began to develop formal management processes or systems designed to address the specific human and team errors commonly made by cockpit crews and placed issues around technical skills on the back burner.

John Lauber was first to coin the term "Cockpit Resource Management", which has since been changed to Crew Resource Management (CRM), but it was Frank Hawkins of Royal Dutch Airlines that pioneered resource management in general. CRM is defined as the process of "using all available resources, information, equipment and people, to achieve safe and efficient flight operations" (Lauber, 1984, p. 20). The first CRM training program developed for the aviation industry was based on Elwyn Edwards' SHEL model of interaction between software (documented operations), hardware (physical resources), environment (external context of the system) and liveware (human operators and crew members) (Helmreich & Foushee, 1993). Edwards' model was later expanded to include a trans-cockpit authority gradient, or TAG, which means that captains must create the best possible working relationship with other crewmembers while at the same time maintaining a balance in authority (Helmreich & Foushee, 1993). Over the next few years more research was conducted and Edwards' model was used as the foundation for developing the CRM programs that are now an industry standard.

Effective CRM ensures that crewmembers learn appropriate information and skills related to leadership, effective team formation, maintenance, problem solving, decision-making and situation awareness (Helmreich & Foushee, 1993). Essentially, resource management programs target pilots' skills and abilities related to the non-technical aspects of flight such as communication. During the 1980's, a number of different CRM training programs were developed and delivered to pilots around the

United States. CRM training focused on how pilots' attitudes impact their behaviours and thus have an impact on flight deck performance. One of the main goals of CRM training is to change negative attitudes toward the non-technical aspects of flight management. For example pilots have the ability to demonstrate effective communication but some choose not to because of their attitude towards communication, hierarchy or teamwork with other crewmembers.

At this time, researchers and industry experts noted the importance of individuals' attitudes towards using non-technical skills as a crucial part of flight management. The perspective that the industry and aviation researchers have taken is that the attitudes towards these non-technical skills is equally as important to flight management as mastering skill performance in areas such as communication, teamwork and decision-making. As a result of this focus on non-technical skills and the attitudes towards them, one of the many goals of CRM became changing negatively held attitudes towards non-technical skills into positive ones. Most current CRM programs focus on changing attitudes to support key non-technical skills such as proper communication behaviours, situation awareness, leadership, stress recognition and decision-making (e.g., Flin, 1995; Lubnau , Okray, 2001).

Non-technical skills and attitudes

Non-technical skills such as proper communication, decision making, leadership and situational awareness are critical group factors that influence flight safety, but attitudes towards these non-technical factors also play a critical role in whether or not an individual intends to engage in proper CRM behaviours. Unfortunately, unlike technical and mechanical failures, breakdowns in non-technical skills remain a common theme in the literature on aviation accident statistics. Sixty to 80 percent of aviation accidents are the result of human error (Foushee, 1984; Freeman & Simon, 1991). More recent statistics indicate that non-technical flight crew performance was the primary cause in 67% of worldwide hull loss[1] aviation accidents, while airplane failure was the primary cause of only 12 % and weather in only 10% of all accidents (Boeing 2002 Statistical Summary, 2003).

It is possible that the CRM's failure to significantly reduce the incidence of human error related accidents is due to the diverse types of CRM training and the lack of a match between training requirements and what is delivered. Currently, no guidelines or set industry standards exist for implementing CRM training, nor are there guidelines or industry standards about the exact content of CRM training. Airlines can develop and implement a tailored form of CRM training that is specific to their needs using whatever methods they choose. Although this seems beneficial, it is difficult to ensure that true CRM concepts and underlying psychological theories are being taught and accepted. The lack of standardization or agreement over the exact content and delivery of CRM training has lead to inadequate and "atheoretical" training programs (Salas et al., 1999 p.163).

A major limitation of the literature on CRM concepts is the lack of both clear definitions and a theoretical foundation for flight management attitudes. Specifically, there is a lack of discussion on the theoretical basis behind how flight management attitudes are formed, changed and related to behaviour in the cockpit. Part of the

[1] Hull Loss – A term used by the NTSB and the FAA in which "An aircraft damaged to the extent that it is not economically feasible to repair it. This includes aircraft destroyed or missing (www.airsafe.com, retrieved January 30, 2004).

theoretical foundation for CRM is based on theories in teamwork and group processes which are clearly discussed in the literature; however this is not the case when looking at the theory behind attitudes and flight management. One of the main principles underlying CRM is that it attempts to change and adapt crewmembers' attitudes toward specific non-technical skills; however, research studies in this area fail to explain the attitude theory underlying their process of changing "unsafe" behaviours. Without a known or strong theoretical foundation, it is difficult to know whether or not the CRM training is actually tapping into pilots' safety attitudes and effectively changing them in a positive direction.

Evaluation of CRM Attitudes

Attitudes are not overtly observable, and must, therefore, be measured using either indirect methods such as behavioural observation or direct methods such as surveys or questionnaires (Azjen, 1991). The flight management attitudes questionnaire (FMAQ) (Helmreich, Merritt, Sherman, Gregorich, & Wiener, 1993) is the most commonly used measure of CRM attitudes within the aviation industry. It is predominately used to evaluate the current status of safety attitudes and as a training evaluation tool (e.g., Salas, Fowlkes, Stout, & Milanovich, 1999). The original FMAQ was developed to specifically measure *cockpit* management attitudes and was therefore, referred to as the Cockpit Management Attitudes Questionnaire (CMAQ) (Helmreich, 1984). It contained a total of 25 Likert scale items intended to measure attitudes towards non-technical skills such as communication, and stress recognition and organisational hierarchies. Example items include: "Casual conversion in the cockpit during periods of low workload can improve crew performance" and "Pilots should feel obligated to mention their own psychological stress or physical problems to other cockpit crew personnel before or during a flight" (Helmreich, 1984, p.587).

In 1988, a revised version of the CMAQ was developed because the existing version did not account for cross-cultural attitudes (Gregorich, Helmreich, & Wilhelm, 1990). A total of six items, which did not contribute to the predictive validity of CMAQ, were replaced with six new items. Gregorich, Helmreich and Wilhelm (1990), conducted an exploratory factor analysis of the revised CMAQ scale and initially found a four-factor solution however, further examination of their results concluded there were only three stable factors. Factor one consisted of items relating to Communication and Coordination (e.g., "Each crew member should monitor other crew members for signs of stress or fatigue and should discuss the situation with the crew member"). Factor two was identified by items related to attitudes towards Command and Hierarchy of the cockpit (e.g., "Crew members should not question the decisions or actions of the captain except when they threaten the safety of the flight"). Factor three includes items related to attitudes towards Recognition of Stress Effects (e.g., "My decision making ability is as good in emergencies as in routine flying situations") (Gregorich, Helmreich, & Wilhelm, 1990).

When CRM was exported to other countries other than the United States, CRM safety attitudes were measured and researchers found that CMAQ did not maintain acceptable levels of validity and reliability, even though the levels of reliability and validity reported in U.S Samples is questionable (Gregorich, Helmreich & Wihelm, 1990). CMAQ items that correlated and loaded on specific subscales were no longer doing so with a sample of Korean pilots (Helmreich, & Merritt, 1998). The authors found the existing version of the CMAQ did not take into account differences in national culture. This was a significant finding, resulting in the first cross-cultural study of safety attitudes (Helmreich & Merritt, 1998) and development of the Flight Management Attitudes Questionnaire (FMAQ).

The FMAQ was developed as an extension to the CMAQ, containing all of the original CMAQ items in addition to new items that were based on Hofstede's (1982) four dimensions of national culture (power distance, individualism, collectivism, uncertainty avoidance and masculinity-femininity) (Helmreich & Merritt, 1998). These new items are said to measure work values thereby reflecting cross-cultural aspects of flight management attitudes. Items related to pilots' attitudes toward automation were also added to the survey. The original version of the FMAQ contained 82 Likert scale items, designed to measure pilot attitudes towards command, communication, stress, rules, automation, organisational climate and work values (Helmreich & Merritt, 1998). The questionnaire has since been revised including the FMAQ 2.0 international version and the FMAQ 2.1 USA/Anglo version.

Following further research and application of the FMAQ 2.1, an additional version was developed, based on the idea that the current version was too long and required too much time to complete. The result was a shorter version termed the Flight Management Attitudes Safety (Short) Survey (FMASS) (Sexton et al, 2001). A factor analysis was used as a data reduction technique to determine which factors within the

FMAQ that had the highest level of predictive validity and reliability and should be kept in the FMASS (Sexton et al., 2001).

The FMASS contains four factors: s*afety culture*, which is defined as "the extent to which individuals perceive a genuine and proactive commitment to safety by their organisation" (Sexton et al., 2001). The second factor is *job attitudes*, which are defined as "the level of satisfaction with the organisation and the individual's reactions to his or her job experience". *Teamwork* is the third factor and is defined as "the level of satisfaction with the quality of teamwork and cooperation experienced with other crew members, gate agents, ramp personnel, flight attendants, dispatch, maintenance, and crew scheduling" (Sexton et al., 2001). The final factor is termed *stress recognition* and is defined as "the extent to which individuals acknowledge personal vulnerability to stressors such as fatigue, personal problems and emergency situations" (Sexton et al., 2001, p. 5-9).

Previous research using the original CMAQ (Gregorich, Helmreich, & Wilhelm, 1990) indicates that there are three stable factors and "good" reliabilities for each of the factors (p. 685). The reliability of these scales can be disputed given that the reported Cronbach's alpha coefficients ranged from .47 to .67, a strong indication of very poor or low reliability. Furthermore, exploratory factor analysis (EFA) results indicate factor loadings ranging from .03 to .67 (Gregorich, Helmreich, & Wilhelm, 1990). Tabachnick and Fidell (2001) state that factor loadings of less than .32 are considered poor, accounting for less than 20 percent of overlapping variance, and loadings above .63 as very good, accounting for at least 40 percent of overlapping variance.

Sexton et al. (2001) conducted a confirmatory factor analysis on the FMASS and confirmed the four-factor solution as suggested by Merritt (1996, as cited in Sexton et al., 2001). In addition, they were able to confirm the factor structure across samples taken from Asia, Northern Europe and South America. Results of the study showed that three of the four factors, safety culture, job attitudes and teamwork, were correlated. Sexton and Klinect (2001) report that although the job attitudes and safety culture subscales are highly correlated (.68), they measure separate and distinct constructs. Factor loadings for the FMASS varied with the lowest value of .28 and the highest value of .77. Sexton et al., (2001) describe the fit of the data as "superior", but only report two fit indices, the TLI (.986) and the RMSEA (.053). These numbers do indicate a good fitting model however; models with good fit should have acceptable fit across a number indices (Loehlin, 1987).

Internal consistency coefficients for each of the scales ranged from .64. to.81. The most commonly used measure of internal consistency or reliability is Cronbach's alpha and scales are considered to have an acceptable level of reliability if the Cronbach's alpha reaches above .80 (Bryman & Cramer, 1994). This indicates that the FMASS has low reliability within each of its subscales. Furthermore, it suggests that it is not measuring responses along a consistent or reliable psychological construct.

Despite its wide spread acceptance and extensive use as a safety attitudes measure, as well as a training evaluation tool, there is only a small amount of empirical evidence to demonstrate and support the publicized validity and reliability of the FMASS. The current study appears to be the first independent analysis of the FMASS. Both the FMAQ and FMASS are available to various airlines and the public for use in researching flight management attitudes. Furthermore, these scales have been adapted and used as attitude assessment tools in other high reliability occupations such as medicine and offshore oil. Flin, Fletcher, McGeorge, Sutherland, & Patey (2003) used an adapted version of the CMAQ called the Operating Room Management Attitudes Questionnaire (ORMAQ). The ORMAQ measures stress, hierarchy, teamwork and error and attitudes toward the organisation. Results of the study by Flin et al. (2003) found the subscales to have poor internal consistency as indicated by the Cronbach alphas ranging from .18 to .54. Due to very low inter-item correlations no exploratory factor analysis was possible and previous research does not discuss a factor structure for the scale (Flin et al., 2003).

The rationale for conducting the current study is that there is a gap in the literature on the psychometric properties, specifically the reliability and validity, of the FMASS. The authors of the scale, Sexton et al. (2001), recognize the need for further scale development of the FMASS, yet an independent analysis of the scale has yet to be done. Research investigating the reliability and validity of the FMASS does not appear to extend past research conducted by the authors. Furthermore the reliability and validity of previous versions (CMAQ and FMAQ) of the FMASS are questionable suggesting that the FMASS may not be a reliable or valid measure of flight management attitudes. This has serious implications for both research and the industries that use the FMASS or modified versions of it. These industries include aviation maintenance, offshore oil and medicine. Without a reliable and valid measure of the constructs considered the backbone behind flight management (safety culture, job attitudes, teamwork and stress recognition), companies may not be getting an accurate assessment of their organisation's flight management attitudes. Additionally an invalid and unreliable measure could impact their assessment of whether or not the CRM training they have implemented has had the desired impact on attitudes. Industries who use this scale assume that there is high level of accuracy in what it claims to measure, and as such is important that researchers developing and providing this tool to the industry have a high level of confidence that their scale measures what it says it measures.

Linking flight management attitudes to performance is still a relatively new area of research within aviation and few researchers have undertaken the task. Sexton and Klinect (2001) conducted a study using two subscales of the FMASS, to investigate the connection pilots' attitudes towards safety culture and job attitudes to performance on Line Operated Safety Audits (LOSA). Line Operated Safety Audits are a behavioural evaluation tool where a subject matter expert collects data on flight management behaviours during a flight (Sexton et al., 2001). Results of the study showed that pilots who reported positive safety culture and job attitudes trapped more errors, made fewer errors, and had better overall performance than those pilots who reported negative attitudes as judged by the subject matter experts. If the FMASS is not a reliable and valid measure of attitudes towards safety culture, job attitudes, teamwork and stress recognition, the results of the study are problematic and not an accurate reflection of the connection between flight management attitudes and performance. The current study had one main objective: To independently examine the psychometric properties of the

FMASS, specifically its validity and reliability, to determine if it is measuring the proposed psychological constructs.

Method

Participants

A total of seven hundred and twenty six pilots completed the FMASS for a response rate of 75%. Participation was voluntary and completed following CRM training sessions (see Appendix A). This sample consisted of approximately nine bases located in various cities across Canada. After the data were screened for outliers the sample included a total of 390 Captains and 286 First Officers, with 666 males, 27 females, and 33 who did not indicate gender (*N* = 726).

A total of 24 French surveys were excluded from the analysis due to a lack of empirical evidence to support the validity and reliability of the French version of the FMASS. Occupational titles including: managers, instructors and those participants categorized as "other" were excluded from the analysis, because of a lack of research available to support this version of the survey's use with a sample other than pilots. Table 1 presents descriptive statistics for the continuous demographic variables. Table 2 presents descriptive statistics for the categorical demographic variables.

Table 1
Descriptive Statistics of Continuous Variables

Participant Demographics	Mean	SD	N
Number of Years at Organisation	8.2	6.41	750
Number of Years in Aviation	16.9	7.41	678
Number of Years on Aircraft Type	5.56	6.45	681

Table 2
Descriptive Statistics of Categorical Variables

Demographics	Frequency	Percentage
Participant Gender		
Male	666	91.7
Female	27	3.7
Base		
Halifax	158	21.8
Toronto	141	19.4
London	39	5.3
Calgary	110	15.2
Montreal	15	2.1
Vancouver	148	20.3
Mirabel (Quebec)	35	4.8
Saskatoon	10	1.4
Victoria	22	3.0
Flying Background		
Military	27	3.7
Civilian	595	82.0
Crew Position		
Captain	390	53.7
First Officer	286	39.4
Pilot Status		
Line Pilot	530	73.0
Management	23	3.2
Instructor	61	8.4
Other	5	.7
Aircraft Type		
Dash 8	489	67.4
F28	106	14.6

Measures

The version of the FMASS used in the current study contains a total of 70 items[2]. Twenty- five of those items make up the four factors, while the remaining items are not included in the proposed structure. These items are considered to provide important qualitative information to various stakeholders within the industry and are included as part of the survey (Sexton et al., 2001).

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[2] A revised version of the scale has since been developed and is available (Sexton et al., 2001).

The FMASS requires participants to complete three sections. The first section, (Section A), asks participants to evaluate their level of satisfaction with different aspects of flight operations (e.g., quality of new hire training) using a five point Likert scale, ranging from "A" very low to "E" very high. The second section, (Section B), asks participants to rate the quality of teamwork and cooperation with various other flight management personnel (e.g., gate agents) using a five point Likert scale, ranging from "A" very low to "E" very high. Section three, (Section C), asks participants to provide ratings of items also using a five point Likert scale ranging from "A" disagree strongly, to "E" agree strongly. Sample items include: "I am proud to work for this organisation" and "My suggestions about safety would be acted upon if I expressed them to management". The FMASS technical report (Sexton et al., 2001) does not indicate a total scale reliability coefficient; however, Cronbach alphas are reported for each subscale (safety culture $\alpha = .78$, job attitudes $\alpha = .81$, teamwork = .75, and stress recognition $\alpha = .64$).

Procedure

An archival data set provided by a local organisation was used in the current study. The organisation was responsible for all data collection procedures and proper maintenance of obtained data.

Data Analyses

Using Statistical Package for the Social Sciences (SPSS) Version 10.0 (SPSS, 1999), the data were cleaned by examining minimum and maximum response values, ranges, means, standard deviations, skewness, kurtosis, and standardized scores. Cases with incorrect data were corrected by cross-referencing with the actual questionnaires and cases considered outliers were deleted from further analyses. Outliers were defined as cases having a z score of 3.5 or higher. Multivariate outliers were checked using Mahalanobis distance and none were found. A total of six variables had a skew value above 2 and a kurtosis value above 6; however, all but one of these items are omitted from the factor structure (Wilhelm, Helmreich & Merritt, 2001) as they are considered qualitative items. Item 27 ("I am less effective when stressed or fatigued") was negatively skewed, with a value of –2.37, but due to the robustness of the statistical techniques, and the large sample size, skew was not considered to have a significant effect on the findings (Tabachnick & Fidell, 2001).

A Confirmatory Factor Analysis (CFA) using maximum likelihood estimation was performed on the data using EQS 6.1 for Windows (Bentler & Wu, 2004) in order to confirm the proposed factor structure indicated in the FMASS report. With CFA, a good fitting model is indicated by the comparative, proportion of variance accounted and parsimony fit indices provided by the analysis (Tabachnick & Fidell, 2001). The following fit indices were examined in the current CFA:

1. Root Mean Square Error of Approximation (RMSEA) – is a comparative fit index that estimates the lack of fit in a model compared to a perfect or saturated model; it is able to account for model parsimony and it is able to detect improperly specified models and is often cited within the literature (Tabachnick & Fidell, 2001). Values of less than .06 indicate a good fitting model.

2. Comparative Fit Index (CFI) – is a comparative fit index that assesses fit in comparison to other models using a non-central chi-square distribution. Values higher than .95 indicate a good fitting model.
3. Normed Fit Index (NFI) – is a fit index developed by Bentler-Bonett (1980) to evaluate the estimated model by comparing chi-square values from the model to the independence model (Tabachnick & Fidell, 2001). A value greater than .9 is considered to be a good fitting model.
4. Goodness of fit index (GFI) – is a fit index that indicates the proportion of variance accounted for by examining the properties of the sample and estimated correlation and covariance matrices (Tabachnick & Fidell, 2001). Similar to the NFI good fitting models will have a GFI of at least .9.
5. Standardized Root Mean Square Residual (SRMR) – is a fit index based on residuals and examines the average difference between the observed variances and covariances and the estimated variances and covariances (Tabachnick & Fidell, 2001). A small RMR value, less than .08, indicates a good fitting model.

Following the CFA, an exploratory factor analysis was performed to examine the factor structure of the FMASS. Internal consistency values (Cronbach alpha coefficients) for the overall scale as well as each subscale were also computed. A correlation matrix generated correlations between each of the items and each of the subscales of the FMASS.

Results

A CFA was performed using maximum likelihood estimation and was unable to confirm the proposed four-factor solution. Initial CFA results indicate a poor fit to the data; Table 3 summarizes the fit indices wherein all were below the cut off values of .90 and above

.06. All factor loadings were significant at $p < .01$ and values ranged from .035 to .755 (see Table 4). A total of three variables have factor loadings below .32 as highlighted in Table 4.

Table 3
Fit Indices for Proposed 4 Factor FMASS Model

Fit Indices	Proposed 4 Factor Model
RMSEA 90% confidence interval	.064-.072
RMSEA	.068
SRMR	.066
GFI	.885
CFI	.761
NFI	.707
Chi-square	1064.56 (df = 269)

Table 4
Standardized Factor Loadings for FMASS Items

	Factor Loadings			
Item	Safety Culture	Job Attitudes	Teamwork	Stress Recognition
1. The managers in flight operations listen to us and care about our concerns	.697			
2. My suggestions about safety would be acted upon if I expressed them to management	.735			
3. Management will never compromise safety concerns for profitability	.431			
4. I am encouraged by my supervisors and coworkers to report any unsafe conditions I observe	.640			
5. I know the proper channels to report my safety concerns	.534			
6. I am satisfied with Chief pilot and assistant chief pilot availability	**.035**			
7. I am proud to work for this organization		.758		
Pilot morale is high		.569		
8. Senior management (VP and above) at this airline is doing a good job		.721		
9. Working here is like being part of a large family		.532		

	Factor Loadings			
Item	Safety Culture	Job Attitudes	Teamwork	Stress Recognition
10. I like my job		.556		
11. Pilots trust senior management at this airline		.638		
12. Teamwork with other cockpit crew members			.387	
13. Teamwork with gate agents			.324	
14. Teamwork with ramp personnel			**.219**	
15. Teamwork with flight attendants			.356	
16. Teamwork with dispatch			.721	
17. Teamwork with maintenance			.620	
18. Teamwork with crew scheduling			.613	
19. I am more likely to make judgement errors in abnormal situations or emergency situations				.527
20. My decision making ability is as good in emergencies as in routine flying conditions				.552
21. I am less effective when stressed or fatigued				**.222**
22. My performance is not adversely affected by working with an inexperienced or less capable crewmember				.433
23. Personal problems can adversely affect my performance				.488
24. A truly professional crewmember can leave personal problems behind when flying				.449

Inter-factor correlations were examined and results indicate that each of the four subscales was significantly correlated, however only safety culture and job attitudes were highly correlated (see figure 1). A third factor analysis was conducted combining the job attitudes and safety culture subscale into one factor. The purpose was to test whether or not the two subscales were multicollinear and would provide better fit to the data as a three factor scale. Results not only showed poor fit to the data, but indicated worse fit than the original four factor model, suggesting that the subscales are highly related but separate constructs (see Table 5).

Table 5
Fit Indices for 3 Factor Model

Fit Indices	Tested 3 Factor Model
RMSEA 90% confidence interval	.069-.077
RMSEA	.073
SRMR	.069
GFI	.868
CFI	.721
NFI	.669
Chi-square	1201.49 (df = 272)

The subscales had only a moderate level of internal consistency. The Cronbach alpha for each of the subscales ranged from low to acceptable. Cronbach alphas for each subscale and the entire scale were as follows: safety culture $\alpha = .63$, job attitudes $\alpha = .79$, teamwork $\alpha = .68$, stress recognition $\alpha = .59$, entire scale $\alpha = .68$. Not surprisingly, items "I am satisfied with Chief pilot and assistant chief pilot availability" (SAQ6) and "I am less effective when stressed or fatigued" (SCQ27), which had low factor loadings, were also items decreasing the alpha coefficients, making their respective subscales less reliable. This further supported deleting these items from the scale within the model modification stage. In this particular measure, the low reliability coefficients suggest the items are a poor measure of the proposed psychological constructs and impacting the level of generalizibility.

Model improvement. Modification indices provided by EQS were examined to determine if the model could be improved. The Wald test suggested freeing the variance between item "Level of satisfaction with chief pilot and assistant chief pilot availability" (SAQ6) and the safety culture factor. The LaGrange Multiplier test indicated a number of modifications that would improve the fit to the data such as fixing the variance between variables and factors, however no changes were made on the basis that there was no theoretical support for doing so. Alternatively, variable SAQ6 and the variables with low factor loadings and low R^2 values were deleted on the basis that they were not contributing to the current model, possibly causing poor fit to the data. A total of three items were deleted: "I am satisfied with Chief pilot and assistant chief pilot availability" (SAQ6), " Quality of teamwork and cooperation with ramp personnel" (SBQ16), "I am less effective when stressed or fatigued" (SCQ27), and the analysis was re-run a second time. Fit to the data did improve following the deletion of these variables, however the fit indices remained below suggested cut-off values (see Table 6).

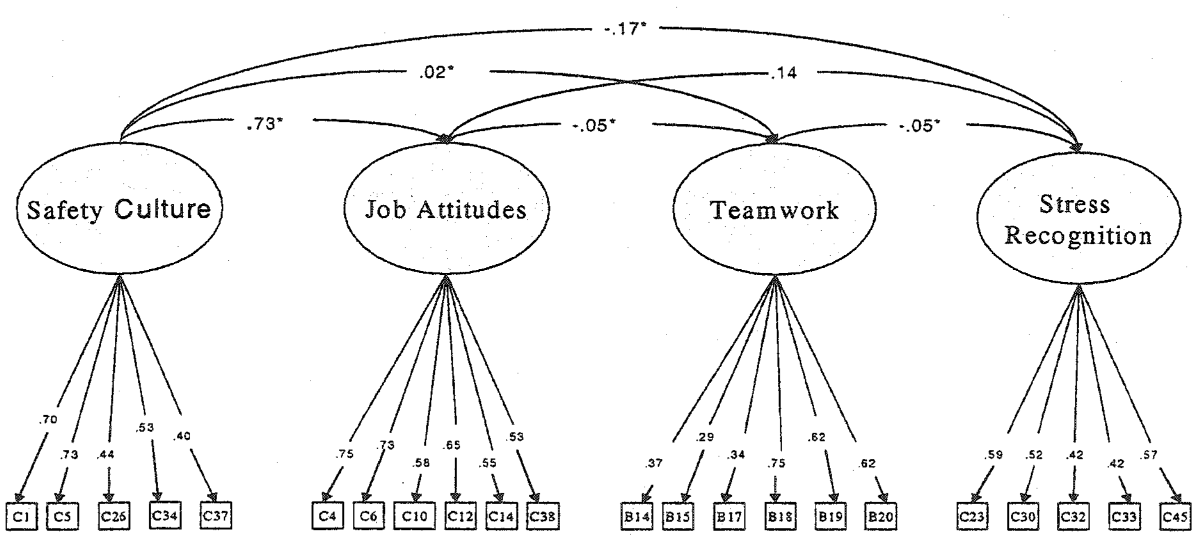
Table 6
Fit Indices for Modified FMASS Model

Fit Indices	Proposed 4 Factor Model
RMSEA 90% confidence interval	.054 - 064
RMSEA	.059
SRMR	.054
GFI	.915
CFI	.847
NFI	.796
Chi-square	665.18 (df = 203)

Again, factor loadings and R-squared values were examined and results demonstrated that one variable SBQ15 "quality of teamwork with gate agents" was not contributing to the overall model. Subsequently, that variable was deleted and another CFA was run. Although fit to the data did improve, fit indices were still below the cut-off values. No further changes were made to the model.

The current sample was unable to confirm the proposed four-factor solution despite a number of changes and modifications to the scale (see Figure 1). This prompted an examination of the data using an exploratory factor analysis (EFA) in order to fully inspect the factor structure and to further investigate the potential multicollinearity of the safety culture and job attitudes subscales.

Figure 1
Best Fitting Model of FMASS



Exploratory Factor Analysis of the FMASS

Inter-item correlations were examined to determine the suitability for conducting an exploratory factor analysis. Having too many low inter item correlations (below .30) indicates that there are no factors to analyse. Correlations that are too high (.90) suggest multicollinearity (Tabachnick & Fidell, 2001). Results showed that there were correlations between items above .30, providing support for the factorability of the data and continuation of the exploratory factor analysis. The initial EFA using principal axis factoring, oblique rotation and listwise deletion, did not demonstrate a clean four-factor solution. A seven-factor solution was extracted, accounting for a reasonable amount of total variance, 40.73 %. Variance accounted for by each of the factors was as follows: factor 1 accounted for 19.06 %, factor 2 accounted for 5.58%, factor 3 accounted for 5.04 %, factor 4 accounted for 3.57%, factor 5 accounted for 3.06%, factor 6 accounted for 2.40% and factor 7 accounted for 2.03 % of the total variance. Interpretability was limited to two factors. Factor one contained all of items related to job attitudes and factor five contained all of the items related to safety culture. The remaining items did not load cleanly on the remaining factors. The rotated pattern matrix showed that the teamwork items loaded on three separate factors while the stress recognition items loaded on two separate factors. The scree plot indicated a three factor solution further suggesting the remaining factors were unstable and should not be interpreted.

Factor loadings from the rotated pattern matrix ranged in value from very poor (-.24) to good (.75) (see Table 7) with two factors accounting for less than 30 percent of the variance in the variables or items (SCQ26, "Management will never compromise safety concerns for profitability" and item SCQ33, "A truly professional crewmember can leave personal problems behind when flying"). Results also demonstrated that, while the safety culture and job attitude items are significantly correlated, they load on separate factors.

Table 7
Rotated Pattern Matrix for EFA of FMASS

FMASS Items	**Factor Loadings**						
Safety Culture	**1**	**2**	**3**	**4**	**5**	**6**	**7**
1. The managers in flight operations listen to us and care about our concerns					-.52		
2. My suggestions about safety would be acted upon if I expressed them to management					-.54		
3. Management will never compromise safety concerns for profitability					-.24		
4. I am encouraged by my supervisors and coworkers to report any unsafe conditions I observe					-.47		
5. I know the proper channels to report my safety concerns					-.54		
6. I am satisfied with Chief pilot and assistant chief pilot availability					-.47		
Job Attitudes							
7. I am proud to work for this organization	.63						
8. Pilot morale is high	.68						
9. Senior management (VP and above) at this airline is doing a good job	.63						
10. Working here is like being part of a large family	.38						
11. I like my job	.45						
12. Pilots trust senior management at this airline	.67						
Teamwork							
13. Teamwork with other cockpit crew members						.68	
14. Teamwork with gate agents				-.66			
15. Teamwork with ramp personnel				-.76			
16. Teamwork with flight attendants						.63	
17. Teamwork with dispatch			.74				
18. Teamwork with maintenance			.57				
19. Teamwork with crew scheduling			.65				
Stress Recognition							
20. I am more likely to make judgement errors in abnormal situations or emergency situations		.66					
21. My decision making ability is as good in emergencies as in routine flying conditions		.62					

FMASS Items	Factor Loadings						
Safety Culture	**1**	**2**	**3**	**4**	**5**	**6**	**7**
22. I am less effective when stressed or fatigued							.34
23. My performance is not adversely affected by working with an inexperienced or less capable crewmember		.33					
24. Personal problems can adversely affect my performance							.75
25. A truly professional crewmember can leave personal problems behind when flying		.28					

A second EFA was performed forcing the number of factors to four, given that the proposed structure of the FMASS contains four factors. The same extraction type, method of rotation and method for dealing with missing data were used. The final solution accounted for 31.56% of the variance. Factor one, *safety culture*, accounted for the most amount of variance at 18.80 %. The percentage of variance accounted for by the remaining three factors was as follows: *Job attitudes* accounted for 5.04%, *teamwork* accounted for 4.59 % and s*tress recognition* accounted for 3.13% of the variance in the total solution.

Although the results of the second EFA demonstrated a slightly cleaner solution, there were low loading items and items that were forced to load on different factors from the previous EFA. Similar to the first EFA, two items accounted for less than 20% of the variance in the item (see Table 7). The items include the same safety culture items as the first EFA, "management will never compromise safety for profitability", and a different stress recognition item, "I am less effective when stressed or fatigued". Forcing the number factors had an impact on the safety culture and stress recognition factors such that items which previously loaded on one factor, loaded on a different factor. For example, safety culture item, "I know the proper channels to report my safety concerns" (SCQ37) was forced to load on the same factor as the stress recognition items where it had not previously loaded. Two teamwork items that previously loaded on their own factor were forced to load onto the safety culture factor (see Table 9). When the number of factors was forced, the results more closely represented the four factors solution proposed by Sexton et al. (2001).

Table 8
Rotated Pattern Matrix for Four Factor EFA

FMASS Items	Factor loadings			
Safety Culture	1	2	3	4
1. The managers in flight operations listen to us and care about our concerns				-.53
2. My suggestions about safety would be acted upon if I expressed them to management				-.48
3. Management will never compromise safety concerns for profitability		**-.25**		
4. I am encouraged by my supervisors and coworkers to report any unsafe conditions I observe				-.51
5. I know the proper channels to report my safety concerns				-.59
6. I am satisfied with Chief pilot and assistant chief pilot availability				-.51
Job Attitudes				
7. I am proud to work for this organization	.64			
8. Pilot morale is high	.65			
9. Senior management (VP and above) at this airline is doing a good job	.60			
10. Working here is like being part of a large family	.33			
11. I like my job	.45			
12. Pilots trust senior management at this airline	.58			
Teamwork				
13. Teamwork with other cockpit crew members			.48	
14. Teamwork with gate agents				-.35
15. Teamwork with ramp personnel				-.38
16. Teamwork with flight attendants			.44	
17. Teamwork with dispatch			.68	
18. Teamwork with maintenance			.58	

FMASS Items	Factor loadings			
Safety Culture	1	2	3	4
19. Teamwork with crew scheduling			.50	
Stress Recognition				
20. I am more likely to make judgement errors in abnormal situations or emergency situations		.54		
21. My decision making ability is as good in emergencies as in routine flying conditions		.54		
22. I am less effective when stressed or fatigued		**.25**		
23. My performance is not adversely affected by working with an inexperienced or less capable crewmember		.40		
24. Personal problems can adversely affect my performance		.49		
25. A truly professional crewmember can leave personal problems behind when flying		**.25**		

Because the current sample contained data from different groups it is possible that the results of the study were impacted by group differences. More specifically, it is possible that there were significant differences between bases and between captains and first officers that impacted the extent to which the data was able to confirm the four factor structure. To deal with this issue of differences between bases, a Multivariate Analysis of Variance (MANOVA) was conducted looking at whether there were group differences between the four largest bases across Canada: Halifax, Toronto and Calgary and Vancouver. Only four bases were chosen due to sample size. Results (see Appendix C) show that there was a multivariate effect, F (3, 553) = 11.17, p <.001, for three of the four subscales: Safety Culture, Job Attitudes and Teamwork. Post hoc analyses indicate that Halifax was significantly different from Toronto, Calgary and Vancouver on the job attitudes and safety culture subscale. The impact group differences had on the factor structure for each base was not further examined due sample size constraints. The impact of group differences between Captains and First Officers was examined using exploratory factor analysis. The factor structure for both occupations differed on the number of factors such that job attitudes and safety culture items loaded on one factor for the Captains. Thus, the results of confirmatory factor analyses were not impacted by the group differences between occupations.

Discussion

The current study had one main objective: To independently examine the psychometric properties of the FMASS, specifically the validity and internal consistency by confirming the four factor solution proposed by Sexton et al. (2001). A confirmatory factor analysis was conducted on the data to confirm that there are four factors to the FMASS. The current study was unable to confirm the four-factor solution as proposed by Sexton et al. (2001) and the scale had a low level of reliability or internal consistency. Initial CFA results indicated poor fit across multiple fit indices, even after various modifications were made, wherein variables with low factor loadings and low R-squared values were deleted from the analyses. Modification indices were ignored in the current analysis due to the lack of theoretical support for the suggested changes. Attention was specifically given to variables with low loadings on the basis that these variables were contributing very little to the overall model.

Following the modifications, fit to the data did improve, but not enough to indicate a good fitting model. The current data was unable to obtain an acceptable level of fit, suggesting that the FMASS is not measuring the psychological constructs it was intended to measure in the current data set.

Reliability analysis demonstrated low levels of internal consistency for all of the subscales, in addition to a low level of internal consistency for the overall scale. Sexton et al. (2001) propose that the FMASS is a reliable measure of four specific components or factors of flight management safety attitudes: safety culture, job attitudes, teamwork and stress recognition. The FMASS appears to be the only currently available measure of flight management attitudes and, as such, is used frequently in both research and applied settings. Reliability coefficients ranged for each of the FMASS subscales ranged from very low to acceptable, suggesting that the FMASS is not consistently measuring the intended constructs across all of the items.

Results of the initial CFA also indicated that two of the FMASS subscales (safety culture and job attitudes) were highly correlated. Sexton et al., (2001) maintain that although they are highly correlated they are distinct constructs. The current study examined this relationship by conducting a CFA combining the two subscales and testing a three-factor model. Results showed poor fit for the three factor model thus suggesting the four factor was more appropriate. Furthermore, an EFA was conducted, which demonstrated that safety culture and job attitudes are related, but separate factors measuring separate psychological constructs. This appears to be supported by the items loading on separate factors, which prompted an examination of the face validity of both the safety culture and job attitude subscale. The items appear to be demonstrating some level of face validity and measuring the intended constructs. For instance, the safety culture items ask respondents to rate their perceptions about the commitment of their organisation to safety (e.g., "My suggestions about safety would be acted upon if I expressed them to management"). The job attitudes items ask respondents to rate their attitudes toward various aspects of their job (e.g., "I am proud to work for this organisation"). It is possible that the safety culture and job attitude are highly related but distinct concepts. It is also possible that the correlation exists because of the predictive relationship between them. In other words, having high perceptions about the level of commitment you feel your organisation has toward safety predicts, in part, attitudes toward your job such as morale. Given the fact that aviation is a high reliability organisation where commitment to safety at all levels of the organisation is critical, it is reasonable to assume that high or positive perceptions of organisational commitment to safety, would positively impact job attitudes such as morale.

The current study was unable to reproduce previous research and confirm a four-factor solution for a number of possible reasons. The most obvious is the lack of reliability of the subscales within the current study and the low to moderate levels of reliability demonstrated in past research. A scale with a low level of internal consistency will not generalize to other samples (Trochim, 2004). Results of the current study showed low levels of internal consistency compromising the extent to the current sample could reproduce the four-factor solution proposed by Sexton et al. (2001). Furthermore, reliability analysis indicates how well a scale is consistently measuring what it was intended to measure. The low reliability coefficients found in the current study suggests the items are doing a poor job of measuring safety culture, job attitudes, teamwork and stress recognition.

Another reason could be the level of construct validity. The FMASS was developed using the FMAQ, which was originally developed from the CMAQ. Although the CMAQ has demonstrated a high level of validity in relation to showing a link between attitudes and behaviour (see Helmreich, et al., 1989) a number of changes and revisions have been made to this original version. Literature on the topic does not clearly indicate the process taken to ensure that the underlying constructs of safety culture, job attitudes, stress recognition and teamwork had high levels of construct validity. From one version of the questionnaire to the next there is very little literature available on how the items were developed, written and changed from one version to the next. Many of the items on the FMASS are poorly worded and double barrelled; for example "I am encouraged by my supervisors and co-workers to report any unsafe conditions I may observe" (SCQ34). Supervisors and co-workers in organizations do not exist within the same chain of command, and typically work under different kinds of pressure. For instance, pilots are under an enormous amount of pressure to perform safely every time they fly, but supervisors have to contend with pressure from management to be as efficient and productive as possible. It is conceivable that pilots are encouraged by their co-workers to report any unsafe condition, but not necessarily encouraged by their supervisors. Additionally, section B of the questionnaire requires respondents to rate the quality of the level of teamwork and cooperation they have encountered with various personnel. Teamwork and cooperation are not one and the same, cooperation is one specific aspect of teamwork and as such it would be difficult to assess the two concepts with the same items. There are various ways to improve the scale, however the first step would be to re-evaluate the construct validity and how the scale was developed. Secondly there are many ways in which the wording of items could be improved. Specific problems with each subscale and ways to improve them are provided below.

It is possible that the FMASS does not work with a Canadian sample for cross cultural reasons. This argument is quickly refuted as the psychometric properties of the FMASS were examined using samples from North America, Asia, Northern Europe, and South America all of which were able to confirm the proposed four factor solution (Sexton et al., 2001). Although it is unknown whether the North American sample in Sexton et al. (2001) contained Canadian data, it is unlikely that any differences between Canada and other North American countries were different enough to cause the failure to confirm the proposed factor structure.

Suggestions for Improvement

Construct Validity. Given the results of the current study there is considerable room for improvement on the FMASS starting with a re-analysis of its construct validity. More research needs to be conducted to examine whether the FMASS is actually measuring the psychological constructs it is proposing to measure. The FMASS purports to measure four underlying psychological constructs however, it is not clear whether the subscales included are actually measuring those constructs. For instance, safety culture is an extremely broad topic, which has no definitive organisation, only common themes (Yule, 2003). In general, safety culture is defined as an organisation's overall shared attitudes, values, beliefs and behaviours around safety (Yule, 2003). Sexton et al. (2001) define safety culture as the "extent to which individuals perceive a genuine and proactive commitment to safety by their organization" (p.3). This definition is only measuring perceptions about one aspect of safety culture: commitment. It does not cover other areas of safety culture including, espoused values, or beliefs. Because safety culture is such a global facet of an organisation it is extremely difficult to measure and when it is being measured most often it is actually safety climate not safety culture. Based on the operationalisation provided by the authors of the scale it appears this subscale is measuring climate not culture.

Safety climate is considered a component of safety culture but is situationally based and refers to the perceptions, operations, working practices, and work environment at a particular point in time (Yule, 2003). When comparing the current safety culture subscale to other measures of safety climate there are notable differences. For instance, Flin, Mearns, O'Connor and Bryden (2000) found that areas most often measured by climate scales include: management/supervision, safety systems, risk, work pressure, and competence. When comparing other measures of safety climate to the FMASS safety culture subscale a number of differences surface. The current subscale contains only six items which is far fewer than many of the other measures (see Flin et al., 2000). Furthermore, other measures of safety climate measure a number of areas including those mentioned above. As stated within the definition the current scale only measures respondents' perceptions of managements' commitment to safety, which is only one part of a multi-faceted construct and only covers management. Furthermore, the questionnaire requires respondents to comment on the commitment they perceive their "organization" to have; however the items only cover management. Managers are not the only employees who contribute to safety culture within an organization.

Improvements to the scale should start with the construct definition by either broadening the scope or narrowing it. If the construct definition is broadened more items need to be included to cover all of the areas that exist within safety culture. Also, if the purpose of the scale is to measure commitment from the entire organisation, more items that measure perceptions of other employees' commitment (e.g. co-workers, supervisors) should be added. If the construct definition is narrowed, the definition should be renamed and be more specific and state that it only covers one specific aspect of safety culture (i.e. management commitment).

The results of the current study has serious potential serious implications for the aviation industry. For instance, airlines who use the FMASS as an attitude assessment tool and who are not familiar with the concept of safety culture might be mislead into thinking that the FMASS is measuring the safety culture of their organisation when in fact it is only measuring one specific facet or component.

In the current study, the job attitudes subscale appears to do a better job of measuring a psychological construct than the safety culture, teamwork and stress recognition subscales. The job attitudes factor is defined as an individual's level of satisfaction with the organisation and their reaction to their job experience. Although the scale does an acceptable job of measuring the proposed construct there is room for improvement beginning with how job attitudes is defined in relation to the items. Job attitudes include a number of different facets beyond satisfaction and morale; such as attitudes toward commitment (e.g. Fields, 2002), organisational justice (Ford, 2001), job involvement (Shore, Newton, & Thorton, 1999). Sexton et al. (2001) does not address any of these facets, nor do they provide justification for not including them as part of the job attitudes factor. Additionally, the operationalisation provided by Sexton et al. (2001) purports to measure satisfaction and morale, but there are three items which do not fall under either facet: "I am proud to work for this organisation", "Pilots trust senior management at this airline" and "Working here is like being part of a large family". These items appear to measure commitment and trust, not satisfaction. Another problem with a scale is that it requires participants to evaluate job attitudes on behalf of all pilots ("pilots trust senior management at this airline") as well as on behalf of their own personal attitudes ("I like my job"). It is possible that a pilot's assessment of their own attitude could differ significantly from other pilots within the same organization. Furthermore, these items require pilots to make a judgement on the attitudes of pilots they are not familiar with, thus bringing into question their suitability for commenting on other pilots' level of trust in senior management. The reliability and validity might improve if the statements included only personal attitude assessment items.

Although the job attitude scale appears to have an acceptable level of reliability, the remaining subscales do not do an acceptable job of reliably measuring the intended constructs and a re-analysis of the theoretical foundation of each subscale is warranted. There are a number of problems that exist with the stress recognition scale in that it is dealing with a number of various aspects of stress. Upon a closer examination of the items within the stress recognition subscale they appear to assess a person's ability to rate their performance while dealing with various stressors or stressful situations. Five of the six items ask respondents to comment on their own ability to perform, but one item requires respondents to comment on crewmembers in general. The construct definition states that it deals only with an individual's perception and the perceptions of others or all "pilots" within the organisation, thus some of the items do not reflect the construct definition.

Additionally the stressors respondents are required to comment on appear random and unorganised. There is no justification or operationalisation provided for what is considered a stressor or why the ones listed were chosen. For instance, one item deals with fatigue, ("I am less effective when stressed or fatigued"), another item deals with inexperience of other crewmembers ("A truly professional crewmember can leave personal problems behind when flying"). Two items include personal problems as a stressor ("Personal problems can adversely affect my performance" and "A truly professional crewmember can leave personal problems behind when flying"). Finally, two items ask respondents to comment on emergency situation as a stressor ("I am more likely to make judgement errors in emergency situations" and "My decision-making ability is as good in emergencies as in routine flying conditions"). Also, two of the items ask respondents to comment on particular aspects of their performance (effectiveness and decision making) while the remaining items require respondents to comment on their performance in general. The scale should be consistent in terms of the specific aspects of performance they are evaluating. Effectiveness is only one of many different aspects of performance. Secondly there are other key areas besides decision making that should be evaluated, including situational awareness, and teamwork.

There are any number of different stressors that exist within a pilots work environment, and rather than having items that appear to reflect random different stressors, the scale should include stressors that fall into specific categories and cover a cross section of those which are most often encountered in their work environment. For instance, the scale should address stressors which are environmental, physical, and psychological. Furthermore, improvements to the scale could be made by asking respondents to comment on their ability to recognise symptoms of stress that are both mental and physical. The focus of the stress recognition scale should be expanded to include more items that tap into the different facets of stress recognition such reporting stress or recognizing stress in other crewmembers.

Similar problems exist with the teamwork scale. In addition to having a poorly defined construct, it attempts to measure a very broad aspect of teamwork with various individuals within the organization who do necessarily interact as a team. The biggest problem with the construct definition is that it requires respondents to comment on the quality of "teamwork" and "cooperation". This is problematic because cooperation could be considered one particular facet of teamwork and not two parallel ideas or concepts. Furthermore "teamwork" is never defined. The scale could be improved in by narrowing the focus to either one specific facet such as cooperation or include various different facets such as communication and leadership

Another problem exists with the teamwork scale in that it requires respondents to rate the quality of teamwork and cooperation with personnel in which the nature of the teamwork based relationships would be different depending on the occupation. For example, the nature of teamwork that pilots experience with other cockpit crew would be inherently different than the teamwork they experience with maintenance personnel or gate agents. Beyond just the quality of cooperation, the amount of direct contact pilots have with gate agents and crew scheduling probably differs significantly from the amount of time pilots spend in direct contact with other cockpit crew and flight attendants.

Improvements to the teamwork subscale should start with the construct definition and increased specificity about how teamwork is defined and what aspects of teamwork is being measured (e.g. quality). The scale could also be improved by having people evaluate teamwork on the basis of the frequency and type of interpersonal interaction they have.

Conflicting information

Conflicting information. When an airline is interested in using the FMASS as an attitude assessment or training evaluation tool, they are provided with a generic scoring report. The report provides information on the items that make up each subscales, how to compute means for the subscales and the internal reliability for the entire scale (Wilhelm, Helmreich, & Merritt, 2001). There is also a technical report on the psychometric properties of the FMASS including reliabilities and factor structure (Sexton et al., 2001), however, when comparing the coding instructions for the FMASS there is conflicting information between the two reports. Instructions within the coding scheme suggest there are 29 items to the FMASS that make up six subscales, yet in the technical report (Sexton et al., 2001) states that there are 25 items that make up four subscales. Furthermore within the generic report four items appear in both the organisational culture subscale as well as the job attitudes. The information provided in the generic report does not indicate the difference between the FMAQ and the FMASS. The coding scheme in the generic report provides no information on the FMAQ or FMASS factor structure or other psychometric properties. In order to obtain this information, it must be requested from the authors in the form of the technical report (Sexton et al., 2001). The FMASS consists of 25 items that load onto four separate factors, and 45 other items that are included despite the fact that they do not load on any factor. These items provide valuable qualitative information about attitudes towards other areas of flight management such following standard operating procedures. When following the generic report, a scoring key is provided for five subscales: safety culture, job attitudes, teamwork, stress recognition, and lastly a command and hierarchy scale. The very same scoring key is provided for both the FMAQ and the FMASS and the report specifically indicates a command subscale exists for both scales. The items, which are said to make up the command scale, are the same on both versions. Interestingly, the report written specifically on the FMASS (Sexton et al., 2001) does not include a command and hierarchy factor and the items are considered to be qualitative items. It is possible that there is a psychological construct relating to command and hierarchy however because of the wording of the items they are not factoring together. This subscale should be taken out of the generic report so that it matches the information provided in the technical report on the psychometric properties of the FMASS (Sexton et al., 2001).

Moreover there are at least two different versions of the FMASS, the version used in the current study, and the version that is provided at the back of the generic report and the technical report (Sexton et al., 2001). These two different versions have the same name but do not contain the same number of items. It appears as though 17 qualitative items which were poorly worded, double barrelled, or contained typos were deleted from the questionnaire. Neither the generic report, nor the technical report indicate that a previous or earlier version of the FMASS was developed and neither report advises that these17 items should not be considered in data analysis or as part of an airline's assessment of safe flight management attitudes.

It is also possible that the current sample was unable to confirm the four-factor solution because a significant organisational change recently occurred. Pilots' responses towards their level of safety culture, teamwork and in particular job attitudes may have been influenced by the shift in the organisation's operations.

Limitations & Future Research

Limitations. Because the current study used data previously collected by the involved airline there was no experimental control of how the sample was recruited and administered the survey. There was no control over instructions given to respondents and no control over the environment in which respondents completed the survey. Despite the large sample size the data was collected from one specific airline and may not be generalizable to other samples of Canadian pilots. The generalizbility of the results are limited due to the low levels of internal consistency, therefore, future research should be done using a different sample of Canadian pilots to ensure the results are not specific to this airline.

Further research should re-examine the theoretical foundation, development and validity of the proposed psychological constructs and the items. It is arguable whether the safety culture, job attitudes, teamwork and stress recognition are measuring an underlying construct or measuring attitudes toward disparate areas that only appear to tap into safety culture, job attitudes, stress recognition and teamwork. Because the FMASS is used as a training evaluation tool the most important next step in research would be to develop a new scale that more accurately measures the important components of safe flight management. In its current form the FMASS does not appear related to the goals of CRM training. Future research should re-evaluate the usefulness of the FMASS as an organisational assessment tool.

Implications. The implications of this study apply to both practical and research settings. The FMASS is a measure frequently within the aviation industry. It is used to assess the effectiveness of training and an organization's present attitudes towards flight safety management. The current study suggests that the reliability and validity of the scale are problematic. An unreliable and invalid measure of the proposed constructs poses problems to the industry as well as researchers. First, decisions around the effectiveness of CRM training may be impacted by the results of the FMASS and as such it is possible that incorrect conclusions about whether CRM is effective could be drawn. Furthermore airlines that use the FMASS to assess the current status of their organization could be mislead in that they are not measuring what the scale purports to measure. Researchers need to be careful and aware of the questionable reliability and validity of the FMASS especially when drawing conclusions about attitudes and performance. Sexton et al, (2001), briefly note the need for further research on the psychometric properties of the FMASS in their technical report, however this is not mentioned within the generic report that airlines receive as guide for analysing survey results. Airlines in particular should be made aware about the uncertainty of the validity and reliability of the FMASS so they are able to make appropriate decisions and conclusions about their organisation.

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Appendix A

Flightdeck Management and Safety Survey

The success of this survey depends upon your contribution so it is important that you answer questions as honestly as you can.

There are no right or wrong answers, and often the first answer that comes to mind is best.

Individual responses are absolutely confidential. If you do not fly an automated aircraft, leave the automation questions blank.

Part I – Pilot Views: This portion of the questionnaire asks you to express your perceptions of the company. Please answer by writing a letter beside each item from the corresponding scale.

A Very Low	B Low	C Adequate	D High	E Very High

A. Please evaluate your level of *satisfaction* with these aspects of flight operations.
quality

_____1. Quality of new-hire training crewmembers
_____2. Ground school
_____3. Simulator-based training
_____4. Fairness of checking
_____5. Flight standards & training overall
_____6. Chief pilot & assistant chief pilot availability
_____7. Flight Operations management

B. Please describe your different Personal perception of the

of teamwork & cooperation you have experienced with:

_____14. Other cockpit
_____15. Gate agents
_____16. Ramp personnel
_____17. Flight attendants
_____18. Dispatch
_____19. Maintenance
_____20. Crew Scheduling

25. Please answer the following by writing a letter beside each item using the following scale.

A Disagree Strongly	B Disagree Slightly	C Neutral	D Agree Slightly	E Agree Strongly

_____1. The managers in Flight Operations listen to us and care.
_____2. Under *abnormal* conditions, I can rapidly access the information I need in/from the FMS.
_____3. Junior crewmembers should not question the captain's decisions.
_____4. I am proud to work for this organization.
_____5. My suggestions about safety would be acted upon if I expressed them to management.
_____6. Senior management (VP and above) at our airline is doing a good job.
_____7. Our pilots and flight attendants work together as a well-coordinated team.
_____8. Crewmembers that I fly with comply with our airline's SOP's.
_____9. I think that it is important to make sure other crewmembers acknowledge my changes to system SOP's.
_____10. Pilot morale is high.

_____11. Checklists should only check critical "safety of flight" items – the rest can be accomplished with flow patterns.
_____12. Pilots trust senior management at our airline.
_____13. Safety at this airline is better now than three years ago.
_____14. I like my job.
_____15. I believe that the benefits of the required before takeoff briefings are overstressed.
_____16. The captain should take physical control and fly the aircraft in emergency and non-standard situation.
_____17. I prefer flying automated aircraft.
_____18. Captains should encourage crewmember questions during normal flight operations and in emergencies.
_____19. It is okay to violate SOP's, as long as the plane lands smoothly and on-time.
_____20. The company's rules (policies and SOP's) should not be broken – even when the employee thinks it is in the airline's best interests.
_____21. Good communication and crew coordination are as important as technical proficiency for flight safety.
_____22. I try to use the highest level of automation as much as possible when I am the PF.

A Disagree Strongly	B Disagree Slightly	C Neutral	D Agree Slightly	E Agree Strongly

_____23. My decision-making ability is as good in emergencies as in routine flying conditions.

_____24. Successful flight deck management is primarily a function of the captain's flying proficiency.

_____25. Crewmembers should not question actions of the captain except when they threaten the safety of the flight.

_____26. Management will never compromise safety concerns for profitability.

_____27. I am less effective when stressed or fatigued.

_____28. I was trained to always use the highest level of automation.

_____29. An essential captain duty is to improve the skills of first officers.

_____30. My performance is not adversely affected by working with an inexperienced or less capable crewmember.

_____31. Automated cockpits require more cross-checking of crewmember actions.

_____32. Personal problems can adversely affect my performance.

_____33. A truly professional crewmember can leave personal problems behind when flying.

_____34. I am encouraged by my supervisors and co-workers to report any unsafe conditions I may observe.

_____35. Except for total incapacitation of the captain, the first officer should never assume command of the aircraft.

_____36. Written procedures are necessary for all in-flight situations.

_____37. I know the proper channels to report my safety concerns.

_____38. Working here is like being part of a large family.

_____39. Crewmembers should mention their stress or physical problems to other crewmembers before or during a flight.

_____40. The captain's responsibilities include coordination.

_____41. If I perceive a problem with the flight, I will speak up, regardless of who might be affected.

_____42. Effective crew coordination requires crewmembers to consider the personal work styles of other crewmembers.

_____43. I feel embarrassed when I make a mistake in front of others.

_____44. It is difficult to know what FMS operations the other crewmember is performing, without discussion.

_____45. I am more likely to make judgment errors in abnormal or emergency situations.

_____46. I believe that the benefits of the required approach briefing are overstressed.

_____47. I am concerned that the use of automation will cause me to lose flying skills.

_____48. I look forward to more automation – the more the better.

_____49. Sterile cockpit SOP is unrealistic and overstressed.

_____50. Even when tired, I perform effectively during critical, high workload phases of a flight.

_____51. There are modes and features of the FMS that I do not fully understand.

_____52. My company expects me to always use the highest level of automation.

_____53. My situational awareness suffers when I am fatigued.

_____54. I let other crewmembers know when my workload is becoming (or about to become) excessive.

_____55. We currently receive too much CRM training.

_____56. Non-jeopardy line observations are a good means of collecting operations and safety data/information.

Part II – Background Information

___ Gender (M or F) _____ Base ____ Years at current airline ____ Years in Aviation

_________________Current Fleet (A/C type & series) _____ Years in position (this aircraft)

Flying background (check one) ___ Military ___ Civilian ___ Both

Crew Position: ___ CA ___ FO ___ F/A

Status: ___ Line Pilot ___ Instructor ___ CAT "A" ___ CAT "B" ___ Management ___ Other

Thank you for taking the time to complete the questionnaire. Your participation is appreciated

Appendix B
Inter-Item Correlation Table

	1. The managers in Flight Operations listen to us and care	4. I am proud to work for this organization	5. My suggestions about safety would be acted upon	6 Senior mgmt at our airline is doing a good job	10 Pilot morale is high	12. Pilots trust senior management at our airline	14 I like my job	26. Management will never compromise safety	27. I am less effective when stressed or fatigued	32. Personal problems can affect performance
1. The managers in Flight Operations listen to us and care	1									
4. I am proud to work for this organization	.389**	1								
5. My suggestions about safety would be acted upon	.508**	.417**	1							
6. Senior at our airline is doing a good job	.422**	.545**	.341**	1						
10. Pilot morale is high	.229**	.414**	.232**	.407**	1					
12. Pilots trust senior management at our airline	.364**	.389**	.372**	.564**	.491**	1				
14. I like my job	.271**	.552**	.303**	.295**	.286**	.252**	1			
26. Management will never compromise safety	.289**	.199**	.323**	.212**	.183**	.332**	.188**	1		
27. I am less effective when stressed or fatigued	-.124**	-.032	-.060	-.025	-.066	-.052	.003	-.173**	1	
32. Personal problems can affect my performance	-.124**	-.151*	-.027	-.080*	-.141**	-.070	-.075	-.144**	.257**	1
34. I am encouraged to report any unsafe conditions	.335**	.298**	.402**	.272**	.144**	.259**	.202**	.185**	.013	.029
37. I know the proper channels to report my safety concerns	.304**	.182**	.279**	.157**	.041	.182**	.145**	.145**	-.012	.036

	1. The managers in Flight Operations listen to us and care	4. I am proud to work for this organization	5. My suggestions about safety would be acted upon	6. Senior mgmt at our airline is doing a good job	10. Pilot morale is high	12. Pilots trust senior management at our airline	14. I like my job	26. Management will never compromise safety	27. I am less effective when stressed or fatigued	32. Personal problems can affect performance
38. Working here is like being part of a large family	.326**	.403**	.296**	.345**	.273**	.315**	.324**	.189**	-.023	-.103**
45. I am more likely to make judgment errors in abnormal or emergency situation	-.047	.026	-.053	.000	.044	-.013	.010	-.112**	.015	.184**
scq23 reverse scored	-.049	-.033	-.051	.014	-.054	-.057	-.059	-.115**	.097*	.182**
scq30 reverse scored	-.103**	-.055	-.101**	-.116**	-.117**	-.102**	-.102**	-.140**	-.112**	.193**
scq33 reverse scored	-.066	-.027	-.026	-.061	-.110**	-.092*	-.040	-.132**	.039	.310**
6. Chief pilot & assistant chief pilot availability	.446**	.267**	.382**	.326**	.145**	.267**	.170**	.204**	-.042	-.066
14. Other cockpit crew members	.137**	.187**	.215**	-.093*	-.089*	.058	.178**	.056	.010	.062
15. Gate agents	.211**	.222**	.170**	.222**	-.129**	.140**	.141**	.100**	.048	.042
16. Ramp Personnel	.249**	.229**	.194**	.305**	.153**	.212**	.132**	.093*	.022	.031
17. Flight Attendants	.089*	.168**	.145**	-.119**	.092*	.036	.135**	.041	.003	-.071
18. Dispatch	.244**	.271	-.259**	-.196**	-.157**	.150**	.216**	.147**	.028	.042
19. Maintenance	.171**	.175**	-.224**	-.162**	-.166**	.131**	.159**	.137**	.043	.070
20. Crew Scheduling	.332**	.267**	.226**	.216**	.169**	.155**	.202**	.139**	-.029	.105**

	34. I am encouraged to report any unsafe conditions	37. I know the proper channels to report my safety concerns	38. Working here is like being part of a large family	45. I am more likely to make judgment errors emergency situations	C23. My decision making ability is good in emergencies	C30. My performance is not affected by working with less capable crewmembers	C33. A professional crew member can leave personal problems behind	6. Chief pilot & assistant chief pilot availability	14. Other cockpit crew members
34. I am encouraged to report unsafe conditions	1								
37. I know the proper channels to report safety concerns	.326**	1							
38. Working here is like being part of a large family	.206**	.208**	1						
45. I am likely to make judgment errors in emergency situations	.004	-.034	-.005	1					
C23. My decision making ability is good in emergencies	-.026	-.050	-.074	.427**	1				
C30. My performance is not affected by working with less capable crewmembers	-.042	-.064	-.077	.240**	.190**	1			
C33. A professional crew member can leave personal problems behind	-.058	.009	-.086*	.157**	.216**	.211**	1		
6. Chief pilot & assistant chief pilot availability	.309**	.312**	.201**	-.072	-.031	-.068	-.078*	1	
14. Other cockpit crew members	.105**	.047	.154**	-.032	-.033	-.041	.026	.190**	1
15. Gate agents	.203**	.157**	.136**	-.018	-.047	-.012	-.027	.191**	.110**

	34. I am encouraged to report any unsafe conditions	37. I know the proper channels to report my safety concerns	38. Working here is like being part of a large family	45. I am more likely to make judgment errors emergency situations	C23. My decision making ability is good in emergencies	C30. My performance is not affected by working with less capable crewmembers	C33. A professional crew member can leave personal problems behind	6. Chief pilot & assistant chief pilot availability	14. Other cockpit crew members
16. Ramp Personnel	.170**	.196*	.194**	-.003	-.010	-.055	-.026	.206**	.094*
17. Flight Attendants	.068	.027	.119**	-.079*	-.094*	-.059	-.049	.124**	.472**
18. Dispatch	.181**	.054	.159**	-.036	-.058	-.106**	-.032	.262**	.241**
19. Maintenance	.142**	.053	.131**	-.048	-.034	-.073	.039	.245**	.239**
20. Crew Scheduling	.191**	.068	.221**	-.064	.040	-.067	-.005	.346**	.191**

	15. Gate agents	16. Ramp Personnel	17. Flight Attendants	18. Dispatch	19. Maintenance	20. Crew Scheduling
15. Gate agents	1					
16. Ramp Personnel	.529**	1				
17. Flight Attendants	.103**	.141**	1			
18. Dispatch	.167**	.059	.236**	1		
19. Maintenance	.113**	.092*	.199**	.482**	1	
20. Crew Scheduling	.222**	.141**	.128**	.493**	.357**	1

Appendix C

Tests for Group Effects

Results of the MANOVA showed that there was an overall multivariate effect of base , $F(3, 553) = 11.17$, $p < .001$. The results for the tests of between subjects indicate that there were significant univariate effects of base on the safety culture, job attitudes and teamwork scales. Post hoc analyses show that base Halifax was significantly different from base Toronto, Calgary and Vancouver on all three subscales. In addition, post hoc tests show that Toronto and Vancouver were significantly different from each other on the teamwork scale. The extent to which group differences impacted the factor structure of the FMASS was not examined due to sample size constraints.