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Aeronautical Decision-making (ADM) Training:

The Identification of Training Needs, Developing a Training Program, and Evaluating the Effectiveness of a Training Intervention

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Ph.D.

Cranfield University
School of Engineering

Ph.D. Thesis

2006

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2002-2006

ABSTRACT

Flying a high-technology fighter with high stakes and under high g-force is not only an issue of skilled psychomotor performance but also of real-time decision-making involving situation awareness, choice amongst alternatives, time pressure and risk assessment. There is no aeronautical decision-making (ADM) training program for military pilots in existence neither in the R.O.C. Air Force nor around the world, although academic research had recognized the training needs for aeronautical decision-making. This research consists of three studies described in six chapters to develop an effective solution for ADM problems in order to improve military pilots' decision-making in a dynamic and time-limited tactical environment.

The first chapter is an executive summary comprised by three studies. The second chapter identified ADM training needs by applied the Human Factors Analysis and Classification System (HFACS). Without good analysis it is impossible to identify precisely the training needs and the nature of the training content required for improving pilots' performance. The third chapter examined five ADM training mnemonics in six different decision-making scenarios for developing an ADM training program. There are many ADM mnemonics available. However, there was lack of empirical research investigating the efficiency of those ADM mnemonics in the real-time tactical environment. The fourth chapter evaluates the effectiveness of ADM training program by simulator trials and pencil and paper trials. The fifth chapter is overall discussion, followed by the final chapter containing conclusions and recommendations.

This research demonstrated that ADM training program did improve pilots' in-flight decision-making performance. Improvements in pilots' situation assessment and risk management were obtained, but these were traded-off for response time. To improve the quality of pilots' decision-making, the ADM training program needs to be coordinated with real-time simulator scenarios training. The findings have demonstrated that the ADM training program significantly improved pilots' situation assessment and risk management. However, it still needs to be established if these performance gains continue to be evident at a later date during actual operations.

ACKNOWLEDGEMENTS

The work described in this thesis was contributed by a large number of people's kind help and wise guidance. In particular, I would like to thank Dr. Don Harris, my supervisor of PHD thesis and mentor for professional ergonomics. Without his full of wisdom advice and sincerely support, I couldn't have achieved my goals for publishing many journal articles and conference papers. I do appreciate the ways he lead me, inspire me and help me. I would also like to take this opportunity to express my special thank to following people who have supported and encouraged me during these years.

- Professor Helen Muir, my department head, who not only support my research works, also encourage me to publish my research findings in the international conferences to establish the foundation for my thesis and accumulate my knowledge and experience for academic research works.

- Dr. Graham Braithwaite, director of Cranfield Safety and Accident Investigation Centre, who support me to attend the professional accident investigation course, help me insight the cross-culture differences in aviation operations and the key issues for conducting accident investigation.

- Dr. Douglas Wiegmann and Professor Scott Shappell, the authors of Human Factors Analysis and Classification System (HFACS), who not only provide me scholarship to attend the HFACS seminar, but also advise me how to conduct HFACS for my research.

- Professor Bor-Shiuan Cheng who has been my tutor for twenty-five years. He not only inspired me toward academic research but also fully supported my research.

- Ms. Aurora S. Chen, my wife, who always create a comfortable home for me to concentrate on my research, although she is still doing her PHD. I do appreciate everything she has done for me.

There are many more people take care of me and support my research, such as all my colleagues in the Human Factors Group who have encouraged and help me all the time; my colleagues, officers and pilots in the R.O.C. Air Force who have encouraged me and participated the ADM experiment to facilitate my study, I also like to express my sincerest gratitude.

LIST OF PUBLICATIONS

A. Journal Articles

(1) Li, W.C. and Harris, D. (2006), 'Pilot error and its relationship with higher organizational levels: HFACS analysis of 523 accidents', *Aviation Space Environmental Medicine,* Vol. 77 (10), p.1056-1061. ***SSCI***

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(6) Li, W.C. and Harris, D. (under review), 'The Evaluation of the Efficiency of a short Aeronautical Decision-making Training Program for Military Pilots', *International Journal of Aviation Psychology.* ***SSCI***

(7) Li, W.C. and Harris, D. (under review), 'The evaluation of the decision making processes employed by cadet pilots following a short aeronautical decision-making training program', *International Journal of Applied Aviation Studies.*

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C. Awards

(1) Best Paper of 77th Aerospace Medical Association Annual Scientific Meeting: Spread the World & Share the Science of Aerospace Medical Association (18th May 2006), Orlando, USA.

(2) Best Student Paper Award of Technical Training Group, 49th Human Factors and Ergonomics Society Conference (30th September 2005), Orlando, USA.

(3) Scholarship of Human Factors Analysis and Classification System (HFACS) Seminar on Managing Human Error in Complex System, Error Management Solution (28th July 2005), Tampa, USA.

D. Qualifications

(1) Register Member of the Ergonomics Society (MErgS), United Kingdom, 30th January 2006.

(2) Aviation Human Factors Specialist issued by European Association of Aviation Psychology, AHFS 016, 1st July 2005.

(3) Certificate of Aircraft Accident Investigation Training (six weeks), Cranfield University (in partnership with Air Accidents Investigation Branches, AAIB), United Kingdom, 1st July 2005.

(4) Certificate of Accident Investigation for Aircrew and Operations Executives (two weeks), Cranfield University (in partnership with Air Accidents Investigation Branches, AAIB), United Kingdom, 12th November 2004.

(5) Certificate of Hazards Awareness at Air Accidents Sites for Air Accidents Investigators, Cranfield University (in partnership with Air Accidents Investigation Branches, AAIB), United Kingdom, November 2004.

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INDEX OF ABBREVIATIONS

AAIB	Air Accidents Investigation Branch
ACM	Air Combat Manoeuvre
ADM	Aeronautical Decision-making
ARTFUL	Awareness, Risk, Time, Further alternative options
BFM	Basic Fighting Manoeuvre
CAA	Civil Aviation Administration
CREAM	Cognitive Reliability and Error Analysis Method
CRM	Crew Resource Management
DESIDE	Detect, Estimate, Set safety objectives, Identify, Do, Evaluate
EGT	Exhaust Gas Temperature
FAA	Federal Aviation Administration
FOD	Foreign Object Damage
FOR-DEC	Facts, Options, Risks & Benefits, Decision, Execution, Check
GCI	Ground Control Intercept
GPWS	Ground Proximity Warning System
HFACS	Human Factors Analysis and Classification System
ISD	Instructional System Development
LOFT	Line Operational Flight Training
LOSA	Line Operations Safety Audit
NDM	Naturalistic Decision Making
NOTECHS	Non-Technical Skills
NTSB	National Transportation Safety Board
PASS	Problem identification, Acquire information, Survey strategy, Select strategy
PRE	Proportional Reduction in Error
RPD	Recognition-Primed Decision
SHOR	Stimuli, Hypotheses, Options, and Response
SOAR	Situation, Options, Act, Repeat
SOPs	Standard Operating procedures
TCAS	Traffic Collision Avoidance Systems
TATC	Tactical Air Traffic Control

CHAPTER I

Executive Summary

1.1 Introduction

To improve flight safety, the Republic of China (R.O.C.) Air Force Headquarters investigates the pattern of mishaps annually. The findings are that military aviation accidents attributable solely to mechanical failure have decreased markedly but those attributable to human error have declined at a much slower rate and remain the primary cause of accidents. The role of human error in aviation accidents is a topic of much scientific debate. There are a number of perspectives for describing and analyzing human errors, each based on different assumptions about their nature and the underlying causal factors of the human contribution in the sequence of events leading up to an accident. For example, Dekker (2001a) has proposed that human errors are systematically connected to features of operators' tools and tasks, and error has its roots in the surrounding system. The question of human or system failure alone demonstrates an oversimplified belief in the roots of failure. The important issue in a human factors investigation is to understand why pilots' actions made sense to them at the time the accident happened (Dekker, 2002). Earlier work by Feggetter (1991) similarly suggested that the role of psychologists who investigate accidents is to collect and make a detailed examination of the large amounts of information associated with human errors and to gain a complete understanding of the surrounding circumstances. To this end many human factors accident analysis frameworks, taxonomies and analysis strategies have been devised over the years (e.g.

Diehl, 1989; Feggetter, 1991; Harle; 1995; Hollnagel, 1998; Hunter & Baker, 2000; Wiegmann & Shappell, 2003).

Prince and Salas (1993) point to the great variability in the nature of the tactical tasks confronting a military pilot. Military pilots make important decisions often using ambiguous information, while under great risk and with very little time. Therefore, decision aids and training are required to provide these pilots with the necessary skills to make quick situation assessments. The topic of aeronautical decision-making (ADM) has assumed a prominent place in current prescriptions for human factors training in aviation. This stems from the finding reported by Jensen and Benel (1977) that the majority of fatal crashes were attributable to decision errors rather than perceptual or action errors. Military pilots must perform a wide array of tasks. Their primary task is to intercept enemy aircraft, attack tactical targets, deliver weapons, troops, or equipment, so flying frequently becomes a secondary task (Kaempf & Orasanu, 1997). Operating a high-technology fighter aircraft with high stakes and under high g-force is not only an issue of skilled psychomotor performance but also real-time decision-making involving situation awareness, choice amongst alternatives and assessment of risk within a limited-time frame (Orasanu & Connolly, 1993). However, aeronautical decision-making has traditionally been viewed as a by-product of flying experience. Only relatively recently has it been regarded as a potential flight-training requirement (Buch & Diehl, 1984).

The model of training development known as Instructional System Development (ISD) adopts what is known as a systems perspective, where training development is viewed as a system that attempts to achieve a particular goal. One of the most well known ISD models is the IPISD (Interservice Procedures for Instructional System Development) model developed by Branson et al. (1975) for training in the U.S. military. The aim of this approach is to provide a generic context-free framework for the development of good training programs. From the perspective of cognitive skills acquisition it is suggested that training will be more effective the greater the extent that the skill required to perform the task can be faithfully reproduced during the training program. This is why the analysis of the task/skill is so important. The contents of such a training program can be identified by either task analysis or by the analysis of performance deficiencies in a real or simulated situation. The focus of the training program has to be both specific and exact so that the training can achieve the training objectives.

There have been many aeronautical decision-making (ADM) theoretical frameworks and ADM training mnemonics discussed in recent years. Most of the research has been based on different perspectives of human information process and has resulted in different strategies for tackling the problem of pilots' decision-making errors. However, there is a lack of empirical research investigating the efficiency of these ADM mnemonics in the real-time tactical environments. Only recently has decision-making been examined as a potential flight-training requirement in the civil aviation. Research suggests that aeronautical decision-making can be improved with training (Cohen, 1993; Endsley, 1995a; Drillings & Serfaty, 1997; Klein, 1993b; O'Hare, 2003; Orasanu & Fischer, 1997; Wagg & Bell, 1997).

The main goal of this research is to develop an effective ADM training program to reduce the number of fatal accidents and incidents related to poor in-flight decision-making by military pilots. There are a series of three studies in this research. Study-1 identifies ADM training needs from the results obtained by the application of the Human Factors

Analysis and Classification System (HFACS). Study-2 identifies the best ADM mnemonic for application in different tactical situations. Study-3 evaluates the efficacy of a short ADM training program for military pilots designed as part of this study.

1.2 Identification of ADM Training Needs by HFACS

Without accurate analysis, it is not possible to identify the ADM training needs and develop the content of training programs required for preventing aviation accidents. HFACS is based on Reason's (1990) system-wide model of human error in which active failures are associated with the performance of front-line operators in complex systems and latent failures are characterized as inadequacies or mis-specifications which might lie dormant within a system for a long time and are only triggered when combined with other factors to breach the system's defences. In study-1, the Human Factors Analysis and Classification System (Wiegmann & Shappell, 2003) has been applied to analyze accidents in the R.O.C. Air Force. To identify training needs the HFACS framework was used to analyse accidents occurring in the R.O.C. Air Force between 1978 and 2002. This was used to provide empirical data describing the strength and causal relationships between categories in adjacent levels of the HFACS to establish how human factors deficiencies in the organizational levels affected categories in lower levels, including pilot's decision-making.

There were a total of 523 accidents analysed in which 1,762 human errors were categorised. Decision errors were involved in 223 (42.6%) of the accidents. Once the significant paths in the HFACS framework have been identified, the development of accident intervention strategies can proceed more rapidly and effectively. The results of this analysis showed that errors of judgment and poor ADM were commonly reported. As a result it was concluded that there was a need for military pilots to be trained specifically in making decisions in tactical environments to improve aviation safety. However, there is currently no empirical research on developing effective ADM training programs for military pilots either in the R.O.C. Air Force or elsewhere.

1.3 The Suitability of ADM training Mnemonics

In study-2, five Aeronautical Decision Making (ADM) mnemonic-based methods were evaluated in six different tactical situations for the purposes of identifying the best approach to form the basis of a decision-making training program. Sixty instructor pilots and 47 cadet pilots from the Republic of China Air Force Academy participated. Participants assessed the suitability of SHOR (Wohl, 1981); PASS (Maher, 1989); FOR-DEC (Hormann, 1995); SOAR (Oldaker, 1996); and DESIDE (Murray, 1997) in the six basic types of decision-making scenario described by Orasanu (1993); go/no go decisions; recognition-primed decisions; response selection decisions; resource management decisions; non-diagnostic procedural decisions, and creative problem-solving. The results suggested that two ADM mnemonics were suitable for covering all basic types of decision. SHOR was rated as being the best in time-limited and critical, urgent situations. DESIDE was regarded as superior for knowledge-based decisions which needed more comprehensive considerations but had time available to do so. There were qualitative differences in the comments regarding the suitability of the ADM mnemonics between instructors and cadet pilots, probably attributable to differences in hazard perception. To optimize training effectiveness, it was suggested that it will be necessary to deliver instruction in using both the SHOR and DESIDE mnemonics and to provide advice concerning which approach is most suitable in which tactical situations.

1.4 Evaluation of the Efficacy of ADM Training Program

In study-3, forty-one fighter pilots from Republic of China Tactical Training Wing participated. Two ADM mnemonic methods, SHOR (Wohl, 1981) and DESIDE (Murray, 1997), that could significantly improve the quality of military pilots' decision-making (Li & Harris, 2005a) formed the basis of an ADM training program. The contents of the training program included (1) an introduction to ADM theories consisting of the Recognition-Primed Decision Model of Rapid Decision Making (Klein, 1993a); The ARTFUL Decision Maker: A Framework Model for Aeronautical Decision Making (O'Hare, 1992); Conflict-theory Decision Making Model (Janis & Mann, 1977); Model of Situation Awareness in Dynamic Decision-making (Endsley, 1997); and Decision Process Model (Orasanu, 1995); (2) the ADM strategies encompassed in SHOR (Wohl, 1981) and DESIDE (Murray, 1997); (3) a case-study practicing SHOR and DESIDE in six basic types of scenarios including go/no go decision, recognition-primed decision, response selection decision, resource management decision, non-diagnostic procedural decision, and creative problem-solving; and (4) Debriefing: the application of ADM in military aviation. The ADM training program lasted approximately four hours in total.

The purpose of this research is to evaluate the effectiveness of the ADM training program using a flight simulator-based experiment (evaluating the products of decision-making) and pencil and paper trials (evaluating the process of decision-making). The results strongly suggest that such a short training course can be effective in terms of improving pilots' skill in situation assessment and risk management. It was however observed that this was at the cost of a decreased speed of responding. The longer-term effectiveness of such courses needs further evaluation to see if it translates into improved decision-making behaviour during day-to-day operations which, ultimately also results in a reduction in the accident rate attributable to poor decision-making. There is also a need to investigate if additional practice in the application of the ADM mnemonic methods in a flight simulator increases the speed of decision-making. Nevertheless, it is suggested that a simple, short, cost-effective training program in the appropriate use of ADM mnemonic methods may ultimately produce significant gains in flight safety. Such a course may easily be integrated into current CRM or simulator-based training programs.

CHAPTER II

The Identification of the Requirement for Aeronautical Decision-making Training by Applying Human Factors Analysis and Classification System (HFACS)

2.1 Introduction

There are two types of analysis that help to identify training needs. The first type of analysis is described as a conventional form of task analysis that breaks down a task into a series of tasks and subtasks. This type of analysis adopts a systems perspective and describes the tasks that have to be accomplished in a logical fashion (Kirwan & Ainsworth, 1992). The second type of analysis focuses on errors in task performance. This can be done at an intra-individual level and also at an inter-individual level whereby errors can be aggregated so that frequent errors can be identified, and a feedback loop is established between the evaluation of performance and the development of training to remedy any weaknesses (Patrick, 2003). This approach to analysis can take place in various ways. Accidents, incidents, and near misses can be analyzed, which provide a rich source of information for subsequent training (e.g., Reason, 1990; Shappell & Wiegmann, 2003).

Analyses of performance errors varies in terms of the range of people sampled, the scope of the activities of interest, the methodologies employed, and whether performance is in a pencil and paper trial, a simulator or an actual aircraft. The Critical Decision Method developed by Klein, Calderwood, & MacGregor (1989) uses retrospective interview data in order to identify the nature of the decision making in an accident or incident. This process tracing approach has been used to analyze cognitive processes involved in decision making and problem solving in an applied setting. The data pertaining to pilot's performance relevant to training provision can be gleaned not only from analysis of actual accidents and near misses but also from experimental studies of performance in simulated situations to scrutinize the types of error so that appropriate training can be devised. Patrick (2003) indicated that training would be ineffective if the linkage between the operational and training environments is degraded in terms of the psychological demands imposed on the pilots. The analysis of training needs is the first step of training development. Without good analysis it is impossible to identify precisely the training needs and the nature of the training content required for improving pilots' performance.

This study applies the Human Factors Analysis and Classification System (HFACS; Wiegmann & Shappell, 1997, 2001a, 2001b, 2001c, 2003; Shappell and Wiegmann 2001, 2003, 2004) to identify the most frequent underlying human factors causes in military aviation accidents or incidents for the purpose of developing potential training solution.

2.1.1 A review of the HFACS Framework

HFACS is based on Reason's (1990) model of human error. Active failures which are associated with the performance of front-line operators in complex systems and latent failures which lie dormant within the system for a long time serve to combine together with other factors to breach a system's defences. As Reason (1997) described, complex systems were designed, operated, maintained, and managed by human beings, so it is not surprising that human decisions and actions at an organizational level are implicated in all accidents. Active failures of operators have a direct impact on the safety of the systems.

However, latent failures are spawned in the upper levels of the organization and are related to management and regulatory structures.

Reason's model was extremely influential in the way that human errors were viewed in aviation accidents but the model did not suggest remedial solutions. Based upon Reason's model, Wiegmann and Shappell (2003) developed the HFACS to service such a need. The system was originally designed and developed as a generic human error framework for investigating and analyzing human error accidents in US military aviation operations (Wiegmann & Shappell, 1997). The same authors later demonstrated its applicability to the analysis of accidents in US commercial aviation (Wiegmann & Shappell, 2001a, 2001b) and US general aviation (Shappell & Wiegmann 2003, 2004). Wiegmann & Shappell (2001b) claim that the HFACS framework bridges the gap between theory and practice by providing safety professionals with a theoretically based tool for identifying and classifying human errors in aviation mishaps. The system focuses on both latent and active failures and their inter-relationships, and by doing so it facilitates the identification of the underlying causes of human error. However, as aviation accidents are the result of a number of causes, the challenge for accident investigators is how best to identify and mitigate the causal sequence of events leading up to an accident. It is important to systematically examine the HFACS framework and identify if this framework is suitable to meet needs for aviation accident classification and investigation.

HFACS examines human error in flight operations at four levels. Each higher level is assumed to affect the next downward level in HFACS framework. The HFACS framework is described diagrammatically in figure 2.1.

- Level-1 ‘Unsafe acts of operators’ (active failures): This level is where the majority of causes in the investigation of accidents is focused. Such causes can be classified into the two basic categories of errors and violation.
- Level-2 ‘Preconditions for unsafe acts’ (latent/active failures): This level addresses the latent failures within the causal sequence of events as well as more obvious active failures. It also describes the context of substandard conditions of operators and the substandard practices they adopt.
- Level-3 ‘Unsafe supervision’ (latent failures): This level traces the causal chain of events producing unsafe acts up to the front-line supervisors.
- Level-4 ‘Organizational influences’ (latent failures): This level encompasses the most elusive of latent failures, fallible decisions of upper levels of management which directly affect supervisory practices and which indirectly affect the actions of front-line operators.

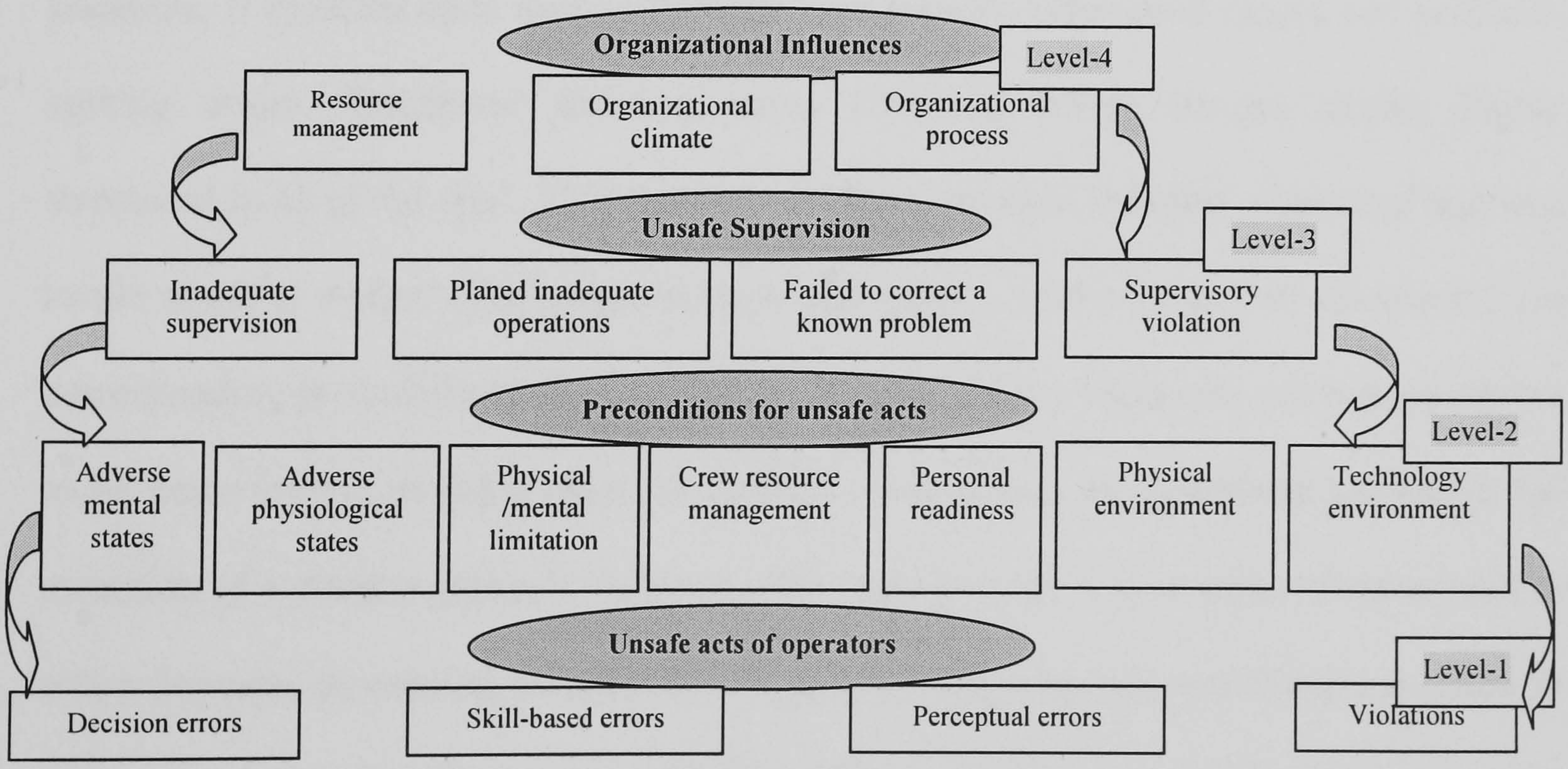


Figure 2.1 The HFACS framework, each upper level would affect downward level, proposed by Wiegmann & Shappell (2003)

2.1.1.1 Level-1 'Unsafe acts of operators'

The first level of 'unsafe acts of operators' can be divided into two sections. Errors represent the mental/physical activities of an individual that fail to achieve the intended outcomes; violations refer to the wilful disregard for the rules and regulations that provide safety of flight (Reason, 1990). However, errors and violations do not provide the level of granularity required of most accident investigations. Wiegmann & Shappell (2003) expanded errors further into the four sub-categories of 'skilled-based errors', 'decision errors', 'perceptual errors', and 'routine and exceptional violations' (figure 2.1). The category of 'skilled-based errors' within the context of aviation is best described as 'stick-and-rudder' and other basic flight skills that occur without significant conscious thought. It also includes attention failures, memory failures, and technique errors; 'decision errors' represent intentional behaviour that proceeds as planned but which is not suitable for the situation. It includes three forms which are poor choices, procedural errors, and problem-solving errors. Procedural decision errors (Orasanu, 1993) happen during highly structured tasks of the type, 'if X then Y'. Military aviation is highly structured and as a result, much of a pilot's decision-making is procedural. However, not all situations have corresponding procedures to deal with them, therefore, many situations still require choice to be made among multiple response options. Sometimes, in ill-defined situations, the invention of a novel solution is required. 'Perceptual errors' occur when sensory input is either degraded or unusual, as is the case with visual illusions and spatial disorientation or when pilots misjudge the aircraft's altitude, attitude, or airspeed. It is important to note that it is not the illusion or disorientation that is classified as perceptual error, rather, it is the pilot's erroneous response to the illusion or disorientation.

There are many ways to distinguish 'violations'. Two distinct forms have been identified, routine violations tend to be habitual by nature and are often tolerated by the governing authority. On the other hand, exceptional violations appear as isolated departures from authority, and are not necessarily indicative of an individual's typical behaviour pattern, nor condoned by management (Reason, 1990).

2.1.1.2 Level-2 'Preconditions for unsafe acts'

Simply focusing on the 'unsafe acts of operator', linked to the majority of accidents, is like focusing on a fever without understanding the underlying illness that is causing it. There is a need to dig deeper into why the unsafe acts occurred in the first place. Wiegmann & Shappell (2003) classified 'preconditions for unsafe acts' into seven further sub-categories of 'adverse mental states'; 'adverse physiological states'; 'physical/mental limitations'; 'crew resource management'; 'personal readiness'; 'physical environment', and 'technological environment' (figure 2.1). The category of 'adverse mental states' was created to account for mental conditions that affect performance, such as loss of situational awareness, task fixation, distraction, and mental fatigue due to stress; 'adverse physiological states' refers to those medical or physiological conditions that preclude safe operations, such as visual illusions, spatial disorientation, physical fatigue, and medical abnormalities known to affect performance; 'physical/mental limitations' refers to those instances when operational requirements exceed the capabilities of the individual at the controls, such as visual limitations, insufficient reaction time, information overload, incompatible physical capabilities and a lack of aptitude to fly; 'crew resource management' was created to account for occurrences of poor coordination among personnel, such as coordination between and within the aircraft, as well as with ATC, maintenance, or other support personnel; 'personal readiness' refers to when individuals fail to prepare physically or mentally for duty, as individuals are expected to show up for work ready to perform at optimal levels. A breakdown in 'personal readiness' includes failures to adhere crew rest requirements, overexertion when off-duty, self-medicating, and inadequate training; 'physical environment' refers to both the operational environment and the ambient environment, such as weather, altitude, terrain, lighting, vibration, and toxins in the cockpit; 'technological environment' encompasses a variety of issues including the design of equipment and controls, display/interface characteristics, checklist layouts, task factors and automation.

2.1.1.3 Level-3 'Unsafe supervision'

Level-3 in HFACS includes supervisor's influence on the condition of pilots and the operational environment. Wiegmann & Shappell (2003) identified four categories of 'unsafe supervision' including 'inadequate supervision'; 'planned inappropriate operation'; 'failure to correct a known problem', and 'supervisory violation' (figure 2.1). The role of supervisors is to provide their personnel with the facilities and capability to succeed and to ensure the job is done safely and efficiently. The category of 'inadequate supervision' refers to a supervisor's failure to provide professional guidance, failure to provide proper training, failure to track the qualifications, lack of accountability, and loss supervisory situational awareness; 'planned inappropriate operation' was created as a category to account for the failures such as poor crew pairing, failure to provide adequate briefing time, risk outweighing benefit, and excessive workload; 'failure to correct a known problem' refers to those instances when deficiencies among individuals, equipment, training or other related safety areas are 'known' to the supervisor, yet are allowed to continue unabated, such as a failure to correct inappropriate behaviour, failure to correct a safety hazard, or failure to initiate corrective actions; 'supervisory violations', on the other hand, are reserved for those instances when existing rules and regulations are wilfully disregarded by supervisors, such as authorizing an unqualified crew for flight, failure to enforce rules and regulations, violation of procedures, and inadequate documentation.

2.1.1.4 Level-4 'Organizational influences'

The decisions of upper-level management can affect supervisory practices, as well as the conditions and actions of operators. However, these organizational errors often go unnoticed due to the lack of framework to investigate them. These elusive latent failures were identified by Wiegmann & Shappell (2003) as 'resource management'; 'organizational climate' and 'organizational process'(figure 2.1). The corporate decisions about resource management are based on two conflicting objectives, the goal of safety and the goal of on-time and cost-effective operations. The category of 'resource management' encompasses the realm of corporate-level decision-making regarding the allocation and maintenance of organizational assets such as human resources (selection, training, and staffing), monetary assets (cost cutting, and lack of funding), equipment, and facilities (poor design, failure to correct design flaws, and purchasing unsuitable equipments); 'organizational climate' refers to a broad class of variables that influence worker performance. An organization's culture and policies are also important factors. Culture really refers to the unofficial or unspoken rules, values, attitudes, beliefs, and customs of an organization. Organizational structure is reflected in the chain-of-command, delegation of authority, communication channels, and formal accountability for action; ‘organizational process’ refers to corporate decisions and rules that govern the everyday activities within an organization, including the establishment of standard operating procedures and formal methods for maintaining checks and balances between the workforce and management.

2.1.1.5 Critical Review of HFACS Framework

Beaubien and Baker (2002) have criticised the validation evidence presented for supporting the utility of HFACS as it has all been collected and analysed by the authors of the system themselves. It was suggested that further inter-rater reliability evidence would be desirable. Wiegmann and Shappell (2001a) reported that the framework as a whole had an inter-rater reliability figure (using Cohen’s Kappa) of 0.71, indicating substantial agreement, however no figures were reported for the individual HFACS categories. Also, Dekker (2003) argued that human error is systematically connected to features of peoples' tools and tasks, and as acknowledged more recently, their operational and organizational environment. Human error classification methods are used throughout aviation to help understand and mitigate the causes of poor human performance, however, many assumptions underlying error classification remain untested. For example, error is taken to mean different things, even within individual methods, and a close mapping is uncritically presumed between quantity measured (error) and the quality managed (safety). Further, error classifications can deepen investigative biases by merely re-labelling error rather than explaining it. The biggest trap in HFACS methods is the illusion that classification is the same as analysis. While classification systems intend to provide investigators more insight into the background of human error, they actually risk making judgments of people instead of providing explanations of their performance (Dekker, 2001b, 2002, & 2003).

2.1.2 Research Purposes

The HFACS framework integrates six major human error perspectives, including the cognitive, ergonomic, behavioural, aeromedical, psychosocial, and organizational perspectives. To date, HFACS has been shown to be useful within the context of US military aviation, as both a data analysis framework and an accident investigation tool (Shappell & Wiegmann, 2003). This study applies the HFACS for analyzing human factors accident data from the R.O.C. Air Force. The first objective was to identify areas for training intervention to help mitigate the instance of human error in military aviation. It was necessary to understand the association of human errors with pilots' tools (aircraft), tasks (missions), ranks (flying experience), and flight stages (environment). The second objective was to provide probabilities for the co-occurrence of categories across adjacent levels of the HFACS to establish how factors in the upper (organizational) levels in the framework affect categories in lower (operational) levels. Once the significant paths in the framework have been identified, the development of accident intervention strategies should proceed more rapidly and effectively. A final objective was to examine the inter-rater reliability of the 18 individual categories of HFACS framework.

2.2 Method

2.2.1 Accident Data

The data were derived from the narrative descriptions of accidents occurring in the R.O.C. Air Force between 1978 and 2002. The data set comprised of 523 accidents during this 25-year period. The sample included 206 class-1 accidents (cost to repair over 65% of original price or crew fatality), 78 class-2 accidents (cost to repair between 35 and 65% of original price or crew sustained serious injury) and 239 class-3 accidents (cost to repair between 3-35% of original price or crewmember sustained minor injury). Fighter aircraft were involved in 67.5% of accidents; training aircraft in 21.6% and cargo aircraft in 10.9%.

2.2.2 Accident Investigation in the R.O.C. Air Force

The Aviation Safety Unit (ASU) is responsible for all R.O.C. Air Force accident investigations. For each accident involving a military aircraft, the 24-hour on call Investigator-In-Charge follows a standard procedure for conducting the investigation. The initial stage collects relevant information for further analysis including the accident classification; identification details; pilots' information; personnel involved; aircraft information; mission and flight details; history of flight; impact and post-impact information; meteorological information; radar information and transmissions to and from Tactical Air Traffic Control. The wreckage of the aircraft is then recovered for investigation by the engineering teams. The final report details the causal factors of the accident and contains recommendations for accident prevention. The data collected include:

- Type of aircraft: the types of aircraft involved in accidents included fighters (F-16, M-2000, IDF, F-104, F-5, etc.), cargo aircraft (B1900, C130, C123, C47, etc.), and training aircraft (AT3, T34, etc.).
- Missions: accidents occurred when pilots' were performing missions that included air interception, air combat tactics, instrument flight, cross country, transition, surface attack, close pattern, test flight, and exercise.
- The flight stages in which accidents occurred included: taxi before take-off, take-off, climb-out, flight in the operational area, decent, approach, landing and taxi after landing.
- The ranks of pilots involved in accidents comprised: cadet, lieutenant, first lieutenant, captain, major, and lieutenant colonel (above).

2.2.3 Coding Process

This study used the HFACS framework described by Wiegmann & Shappell (2003). Each accident report was coded independently by two investigators, an instructor pilot and an aviation psychologist. These investigators were trained on the HFACS framework together for 10 hours to ensure that they achieved a detailed and accurate understanding of the categories in the HFACS. The presence (coded 1) or the absence (coded 0) of each HFACS category was assessed in each accident report narrative. To avoid over-representation from any single accident, each HFACS category was counted a maximum of only once per accident. The count acted simply as an indicator of presence or absence of each of the 18 categories in a given accident.

2.3 Results

A total of 523 R.O.C. Air Force accidents were analyzed including 206 (39.4%) class-1 accidents, 78 (14.9%) class-2 accidents, and 239 (45.7%) class-3 accidents. In these accidents, 1,762 instances of human error were recorded within the HFACS framework. Initial results found that acts at the level of 'unsafe acts of operators' was involved in 725 (41.1%) of instances; the 'preconditions for unsafe acts' level was as a causal factor in 552 (31.3%) of instances; the 'unsafe supervision' level was involved in 221 (12.5%) of instances, and the 'organizational influences' level in the HFACS model was involved as a factor in 264 (15 %) of instances. It must be noted in the following analyses that the percentages quoted refer to the percentage of times that an HFACS factor was implicated in the sequence of events leading up to an accident. However, in most instances many more than just a single factor was implicated in the accident sequence, hence the percentages quoted sum to more than 100% across the results section as a whole.

2.3.1 Sample Characteristics

Fighter aircraft were involved in 353 (67.5%) accidents, training aircraft involved in 113 (21.6%) accidents, and cargo aircraft were involved in 57 (10.9%) accidents. Cadet pilots were involved in 30 (5.7%) accidents, second lieutenants in 10 (1.9%) accidents, first lieutenants in 92 (17.6%) accidents, captains in 144 (27.5%) accidents, majors were involved in 148 (28.3%) accidents and lieutenant colonel (or above) were involved in 70 (13.4%) accidents. Accidents happened during the mission of Air Interception in 44 (8.4%) of cases, Air Combat Manoeuvre in 125 (23.9%) cases, Instrument Flight in 72 (13.8%) cases, Cross Country in 29 (5.5%) cases, Transition Training in 45 (8.6%) cases, Surface Attack in 53 (10.1%) cases, Close Pattern in 30 (5.7%) cases, Test Flight 37 (7.1%) cases, and Exercise in 63 (12%) cases. Accidents happened during flight phase of Taxi before Take-off in 36 (6.9%) cases, Take-off in 64 (12.2%) cases, Climb-off in 28 (5.4%) cases, Operational Areas in 200 (38.2%) cases, Descending in 9 (1.7%) cases, Approaching 55 (10.5%) cases, Landing in 68 (13%) cases, and Taxi after Landing in 61(11.7%) cases.

2.3.2 Causal Factors Associated with HFACS Framework

2.3.2.1 Causal Factors Associated with 'Unsafe Acts of Operators'

In level-1, 'skill-based errors' exhibited the highest frequency of occurrence in the HFACS framework. These included actions such as inappropriate stick and rudder coordination, excessive use of flight controls, glide path not maintained, and adopting an improper airspeed or altitude. 'Decision errors' had the second highest rate of observations. Instances in this category included, selecting inappropriate strategies to perform a mission, improper in-flight planning, making an inappropriate decision to abort a take-off or landing, or using improper remedial actions in an emergency. The category of 'violations' included intentionally ignoring standard operating procedures (SOPs); neglecting SOPs; applying improper SOPs; and diverting from SOPs. The category of 'Perceptual errors' exhibited the lowest frequency of occurrence. This category included experiencing spatial disorientation, visual illusions, making incorrect estimations of distance and descent rate during the approach, and vertigo during tactical maneuvers (figure 2.2).

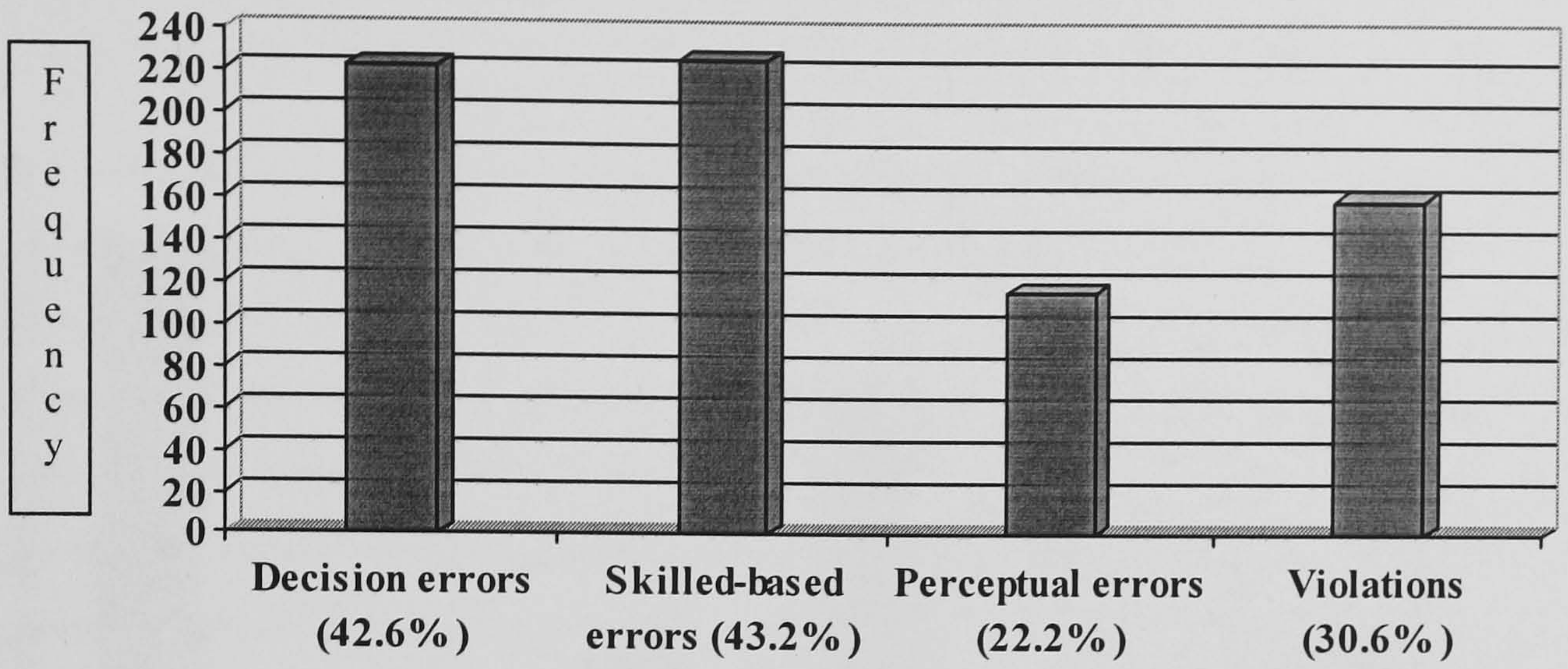


Figure 2.2 Frequency and percentage of factors implicated in accidents at level-1 'unsafe acts of operators'

2.3.2.2 Causal Factors Associated with 'Preconditions for Unsafe Acts'

At level-2 of the HFACS framework, instances of causal factors in the 'adverse mental states' category (the most frequent category of occurrence) included issues such as over-confidence, stress, loss of situational awareness, distraction, channelized attention, and task saturation. 'Crew resource management' (CRM) issues, the next most frequent category, included a lack of teamwork, poor communication, failures of leadership and inadequate briefing. In the 'physical environment' category, contributory factors included poor responses to factors in the environment such as, bad weather, foreign object damage and terrain. The category of 'physical/mental limitations' included instances of visual limitations, information overload and a lack of experience to deal with a complex situation. The 'technological environment' category covered issues such as equipment design, cockpit display interfaces, automation and checklist layout. 'Personal readiness', which encompassed issues associated with inadequate training, self-medication, poor diet, and overexertion while off duty, was involved in relatively few accidents, as was instances of 'adverse physiological states' (figure 2.3).

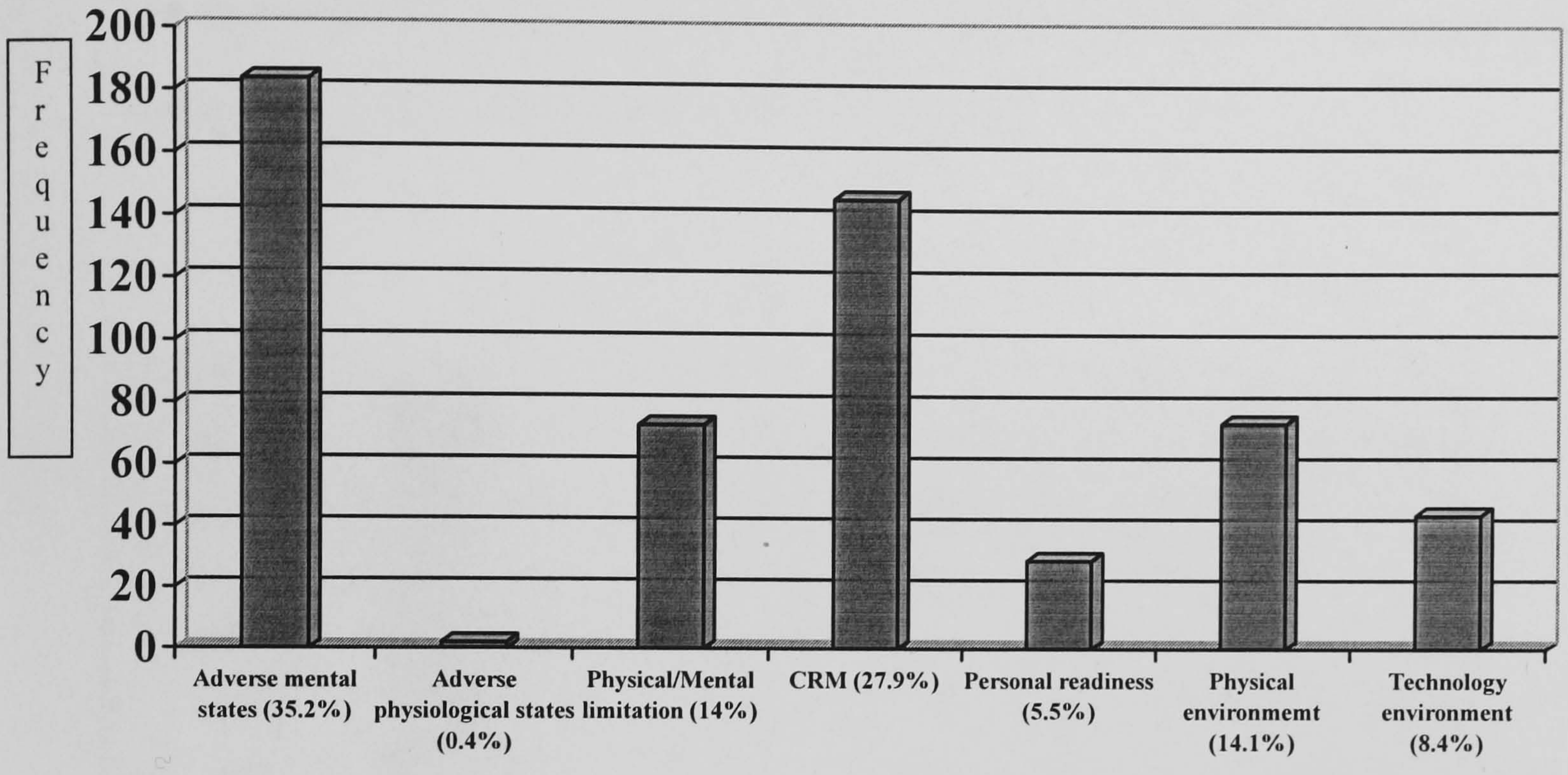


Figure 2.3 Frequency and percentage of factors implicated in accidents at level-2 'precondition for unsafe acts'

2.3.2.3 Causal Factors Associated with 'Unsafe Supervision'

The most frequently occurring category in level-3 was 'inadequate supervision'. Contributory factors included a failure to provide proper training, adequate rest periods, a lack of accountability, failure to track qualifications and performance, using untrained supervisors and loss of situation awareness at the supervisory level. 'Planned inadequate operations' including issues surrounding poor crew pairings, a failure to establish if risk outweighed benefit, excessive task/workload, and failure to provide adequate time for briefing, was the next most frequently occurring category at this HFACS level. In the category of 'failure to correct a known problem', instances included failures to correct inappropriate behaviour, failing to remove a known safety hazard, failing to report unsafe tendencies, and failing to initiate corrective actions. 'Supervisory violations', which included authorizing an unqualified crew for flight, supervisors violating procedures, inadequate documentation, and a wilful disregard of authority by the supervisor, was implicated in relatively few accidents (figure 2.4).

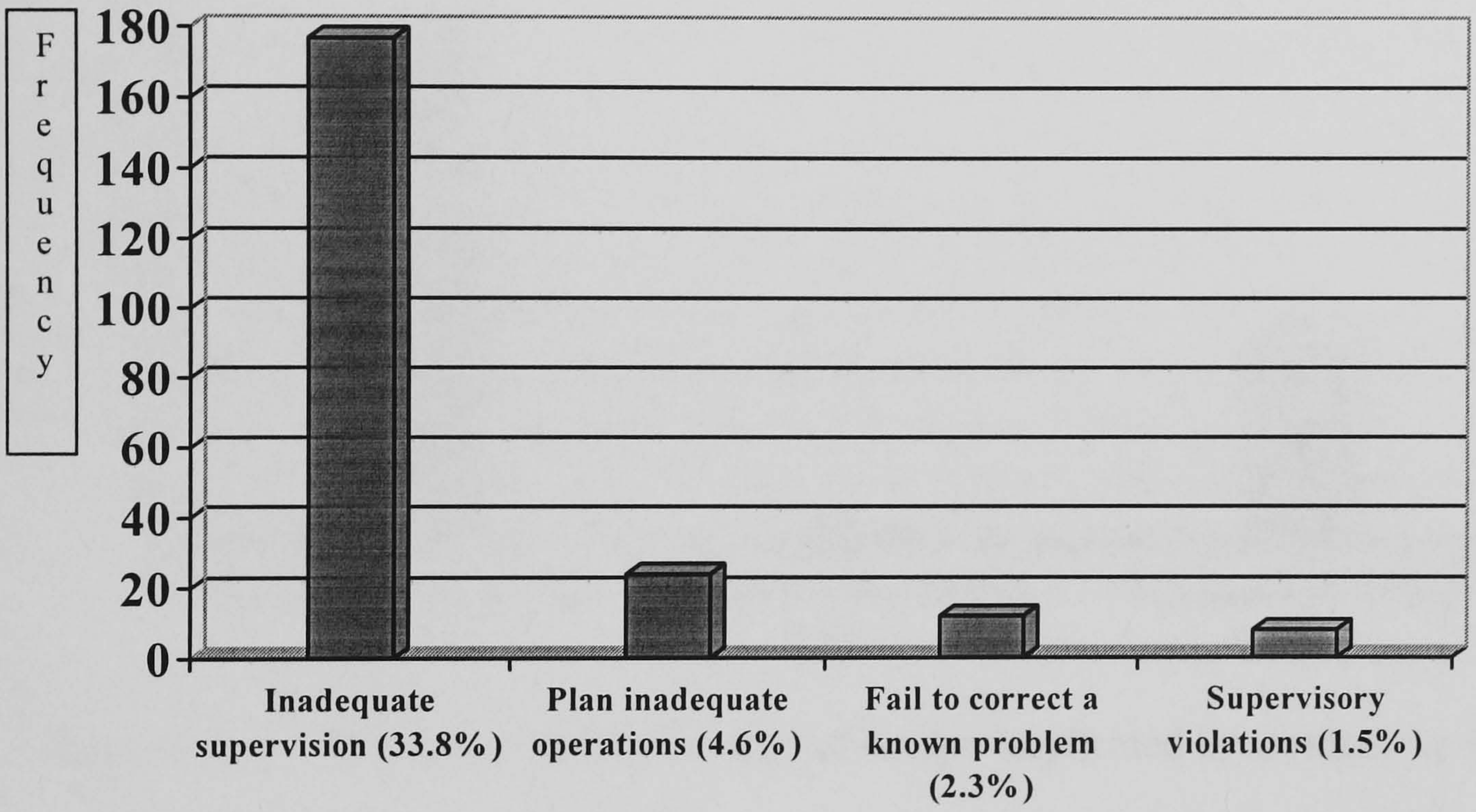


Figure 2.4 Frequency and percentage of factors implicated in accidents at level-3 'unsafe supervision'

2.3.2.4 Causal Factors Associated with 'Organizational Influences'

At level-4, 'resource management', which included the selection, staffing and training of human resources at an organizational level, excessive cost cutting, providing unsuitable equipment, and a failure to remedy design flaws, was most frequently involved in accidents. 'Organizational processes', including excessive time pressures, poor mission scheduling, poor incentivization, failing to set clearly defined objectives, poor risk management programs, inadequate management checks for safety, and failing to establish safety programs, was the next most frequent category at this level in the HFACS framework. Issues surrounding the 'organizational climate' including inadequacies in the chain of command, poor delegation of authority, inappropriate organizational customs and beliefs, and poor accident investigation, were involved in very few accidents (figure 2.5).

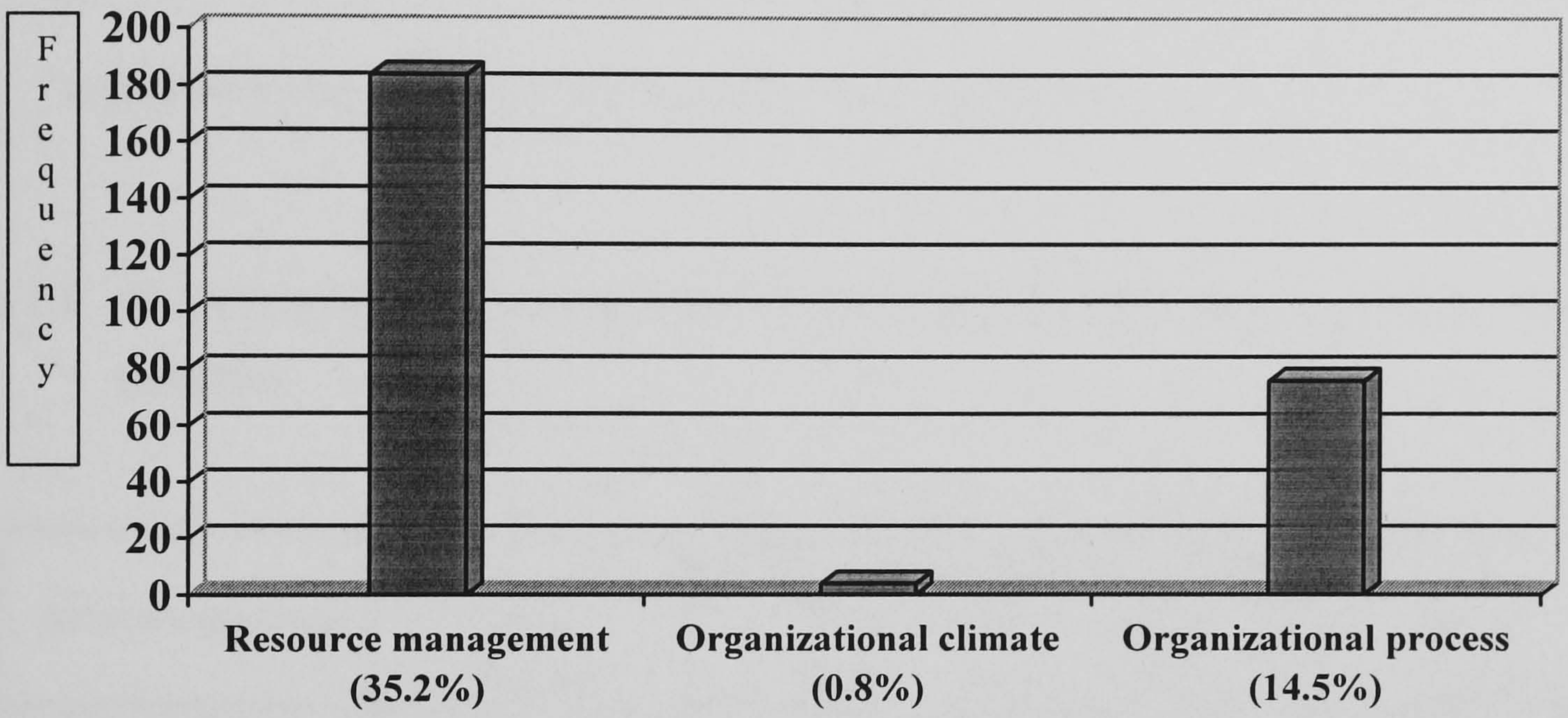


Figure 2.5 Frequency and percentage of factors implicated in accidents at level-4 'organizational influence'

2.3.3 HFACS Framework Versus Demographic Variables

2.3.3.1 HFACS Categories versus Aircraft Types

At the level of 'unsafe acts of operators', there were no significant associations with respect to aircraft type. At the level of 'preconditions for unsafe acts', the associations of aircraft types with 'adverse mental states', 'crew resource management', and 'personal readiness' were significant. Training aircraft pilots were over-represented in having ‘adverse mental states’ and ‘personal readiness’ as causal factors; cargo aircraft pilots were over-represented in having ‘crew resource management’ problems as the major causal factor. At the level of ‘unsafe supervision’, the associations of aircraft type with both ‘inadequate supervision’ and ‘failed to correct a known problem’ were significant. Training aircraft were over-represented in these two categories of accidents. At the level of ‘organizational influences’, the association of aircraft type with ‘organizational process’ was significant. Training aircraft pilots were over-represented in the category of ‘organizational process’ accidents (table 2.1 & figure 2.6).

Table 2.1 Summary of significant associations between HFACS categories and demographic variables

HFACS Categories	**Significant association with HFACS categories**			
	Type of aircraft	Mission	Stage of flight	Rank of pilots
Organizational process	$\chi^2=7.74$, df=2, $p<0.02$			$\chi^2=11.1$, df=5, $p<0.05$
Organizational climate				
Resource management				
Supervisory violation				
Fail correct problem	$\chi^2=20.6$, df=2, $p<0.00$			
Plan inadequate operation				
Inadequate supervision	$\chi^2=8.28$, df=2, $p<0.01$	$\chi^2=20.2$, df=8, $p<0.01$	$\chi^2=34.6$, df=8, $p<0.00$	$\chi^2=26.6$, df=5, $p<0.00$
Technology environment				
Physical environment				$\chi^2=15.1$, df=5, $p<0.01$
Personal readiness	$\chi^2=9.58$, df=2, $p<0.01$	$\chi^2=23.1$,df=8, $p<0.01$		
CRM	$\chi^2=8.35$, df=2, $p<0.01$		$\chi^2=19.6$, df=8, $p<0.01$	
Phy./mental limitation			$\chi^2=17.5$, df=8, $p<0.02$	$\chi^2=32.5$, df=5, $p<0.00$
Adv. physiological state				
Adverse mental states	$\chi^2=7.55$, df=2, $p<0.02$		$\chi^2=25.7$, df=8, $p<0.00$	$\chi^2=18.3$, df=5, $p<0.00$
Violations				
Perceptual errors				$\chi^2=12.5$, df=5, $p<0.02$
Skilled-based errors		$\chi^2=17.1$,df=8, $p<0.02$	$\chi^2=63.6$, df=8, $p<0.00$	$\chi^2=18.1$, df=5, $p<0.00$
Decision errors			$\chi^2=35.7$, df=8, $p<0.00$	$\chi^2=11.7$, df=5, $p<0.03$

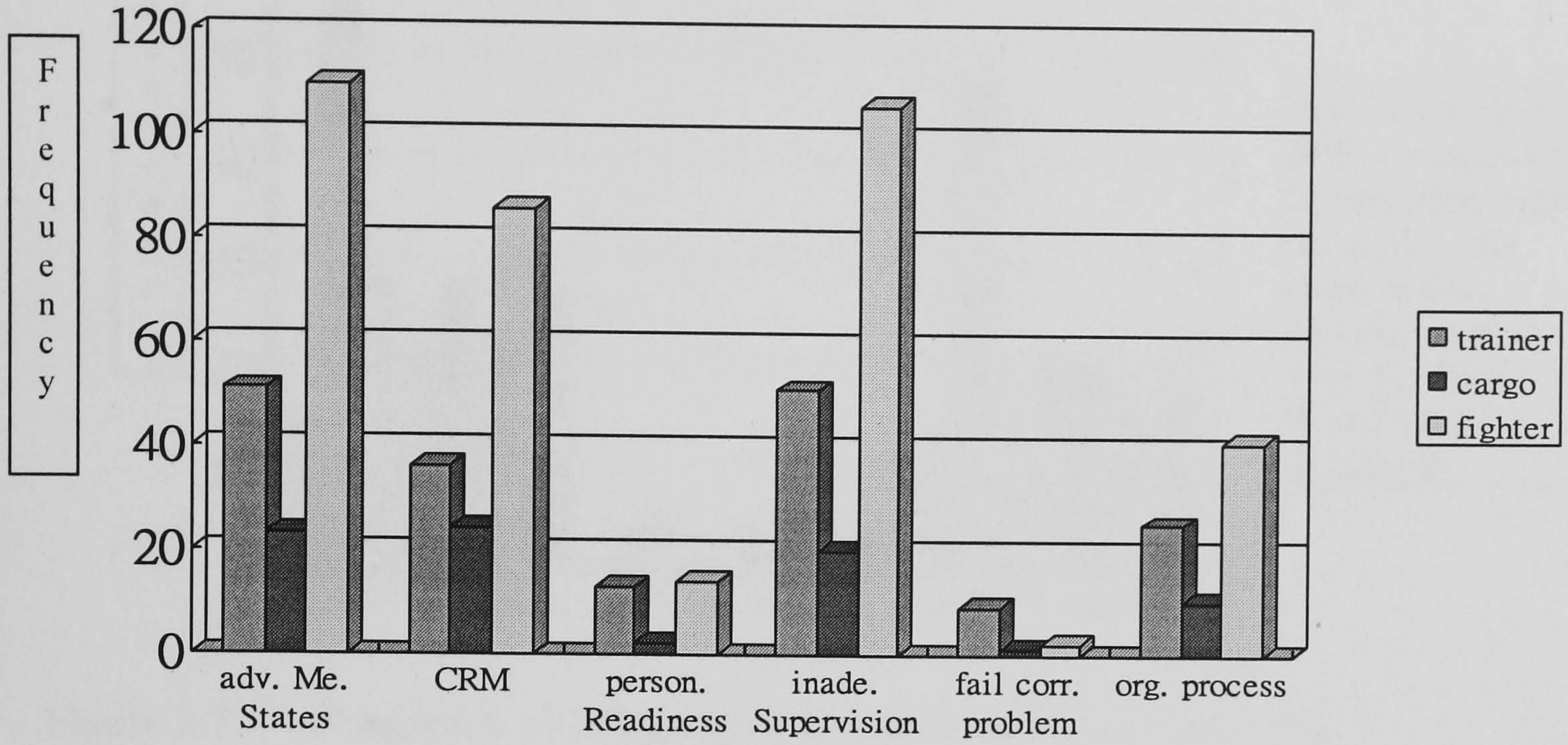


Figure 2.6 Frequency of HFACS categories versus aircraft types

2.3.3.2 HFACS Categories versus Pilots' Missions

At the level of 'unsafe acts of operators', the association of mission with 'skill-based errors' was significant. The 'close pattern' mission was over-represented in the category of 'skill-based errors'. At the level of 'preconditions for unsafe acts', the association of mission with 'personal readiness' was significant. The 'close pattern' mission was also over-represented in the category of 'personal readiness' accidents. At the level of 'unsafe supervision', the association of mission with 'inadequate supervision' was significant. Again, the 'close pattern' mission was over-represented in the category of 'inadequate supervision' accidents. However, at the level of 'organizational influences', there was no significant association between mission and the categories in the HFACS framework (table 2.1 & figure 2.7).

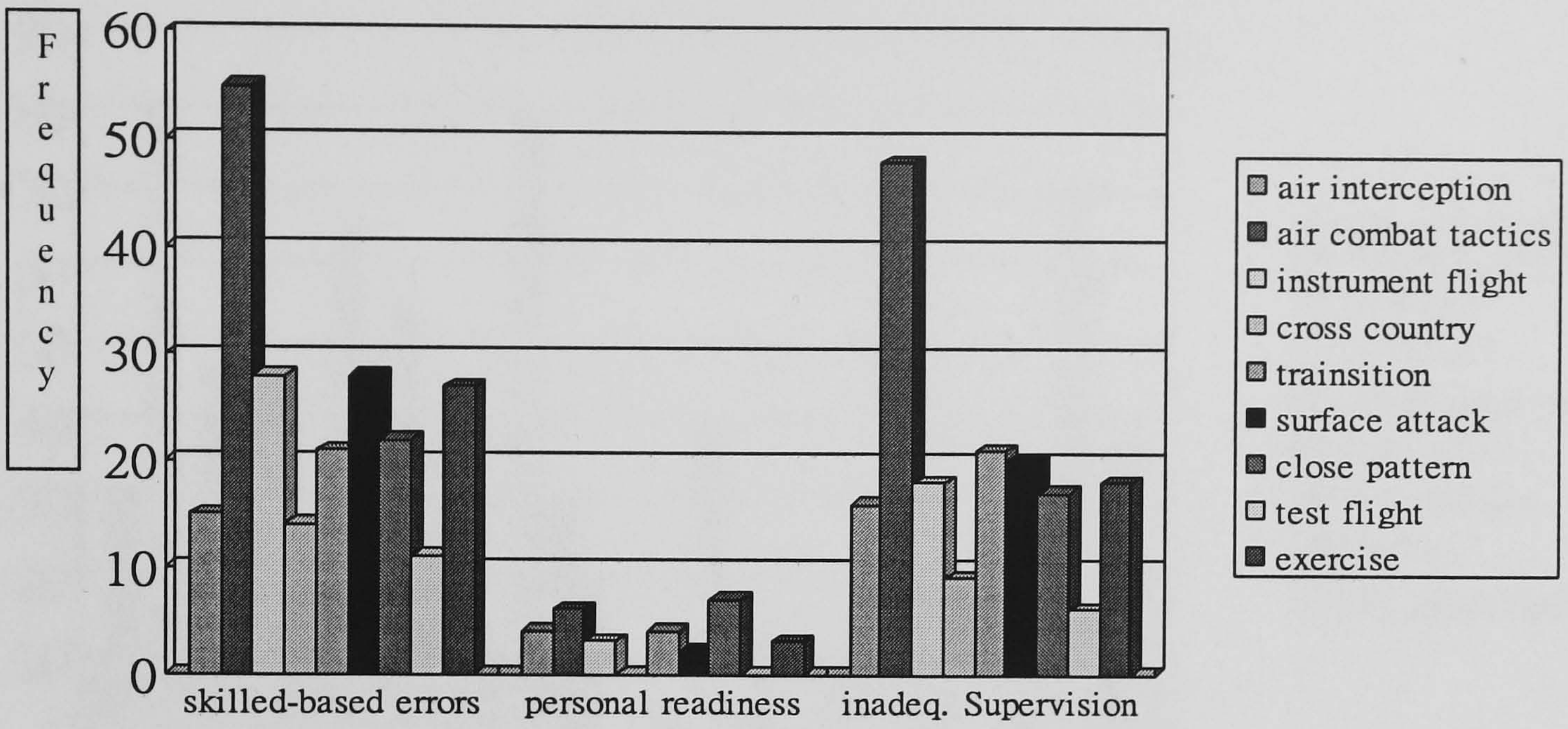


Figure 2.7 Frequency of HFACS categories versus tactical missions

2.3.3.3 HFACS Categories versus Flight Phase

At the level of 'unsafe acts of operators', the associations of flight phase with 'decision errors' and 'skilled-based errors' were significant. The flight phase of 'landing' was over-represented in these two categories of accident. At the level of 'preconditions for unsafe acts', the association of flight phase with 'adverse mental states' was significant, as was the association of flight phase with 'physical/mental limitations' and with 'crew resource management'. The flight phase of 'operational area' was over-represented in these three categories of accidents. At the level of 'unsafe supervision', the association of flight stages with 'inadequate supervision' was significant. The flight phase of 'landing' was over-represented in the category of 'inadequate supervision' accidents. At the 'organizational influences' level, there was no significant association between flight phase and any category within the HFACS framework (table 2.1 & figure 2.8).

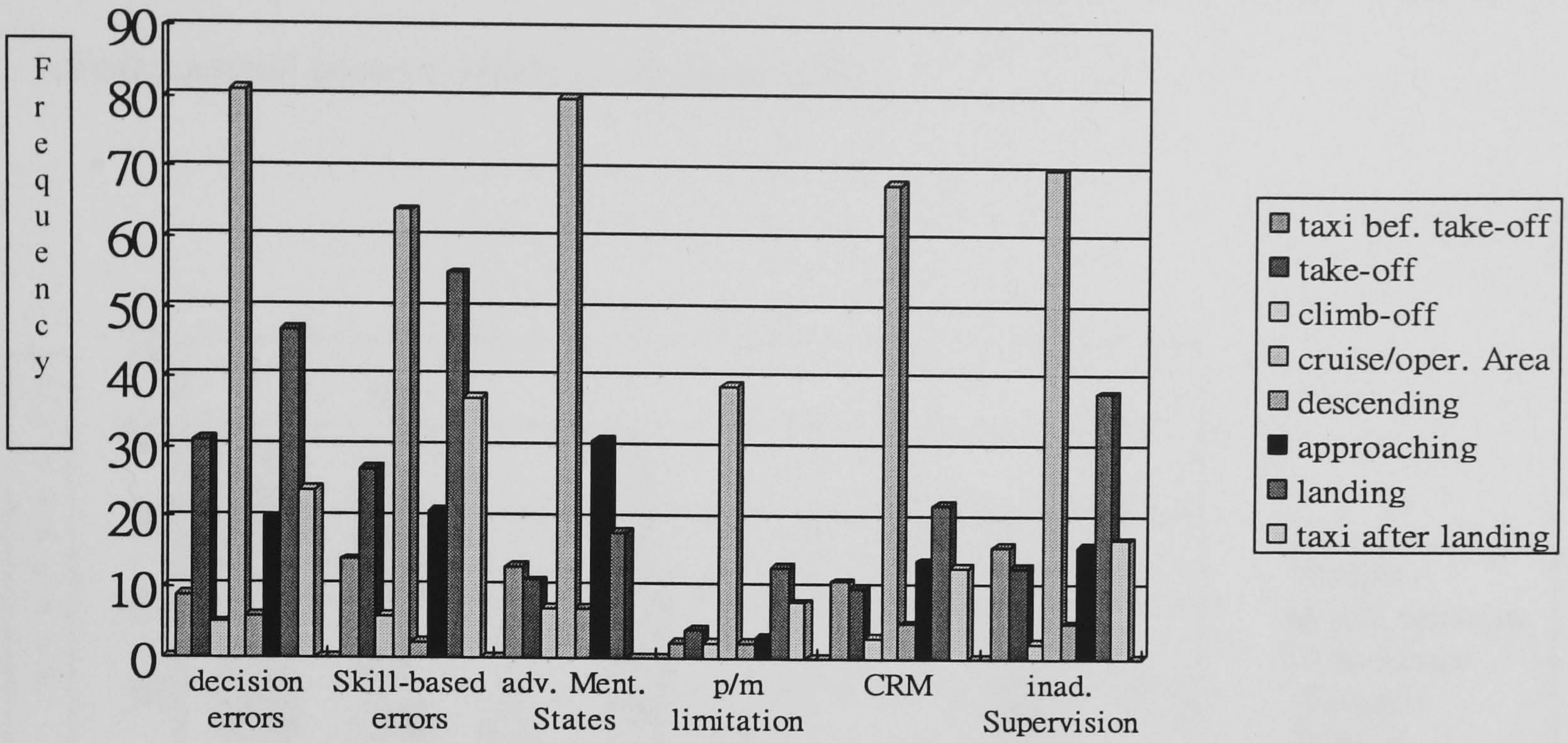


Figure 2.8 Frequency of HFACS categories versus flight phase

2.3.3.4 HFACS Categories versus Pilots' Rank

At the level of 'unsafe acts of operators', the association of a pilot's rank with 'decision errors' was significant, as was the association of a pilot's rank with 'skill-based errors' and with 'perceptual errors'. The rank of 'lieutenant' was over-represented in these three categories of accidents. At the level of 'preconditions for unsafe acts', the association of a pilot's rank with 'adverse mental states', 'physical/mental limitation' and the 'physical environment' were significant. The rank of 'lieutenant' was over-represented in the categories of 'adverse mental states' and 'physical/mental limitation' causal factors of accidents. However, the rank of 'lieutenant colonel above' was over-represented in the category of 'physical environment' of accidents. At the level of 'unsafe supervision', the association of a pilot's rank with 'inadequate supervision' was significant. The rank of 'cadet' was over-represented in the category of 'inadequate supervision'. At the level of ‘organizational influences’, the association of a pilot’s rank with ‘organizational process’ was also significant. The rank of ‘cadet’ was over-represented in the category of ‘organizational process’ (table 2.1 & figure 2.9).

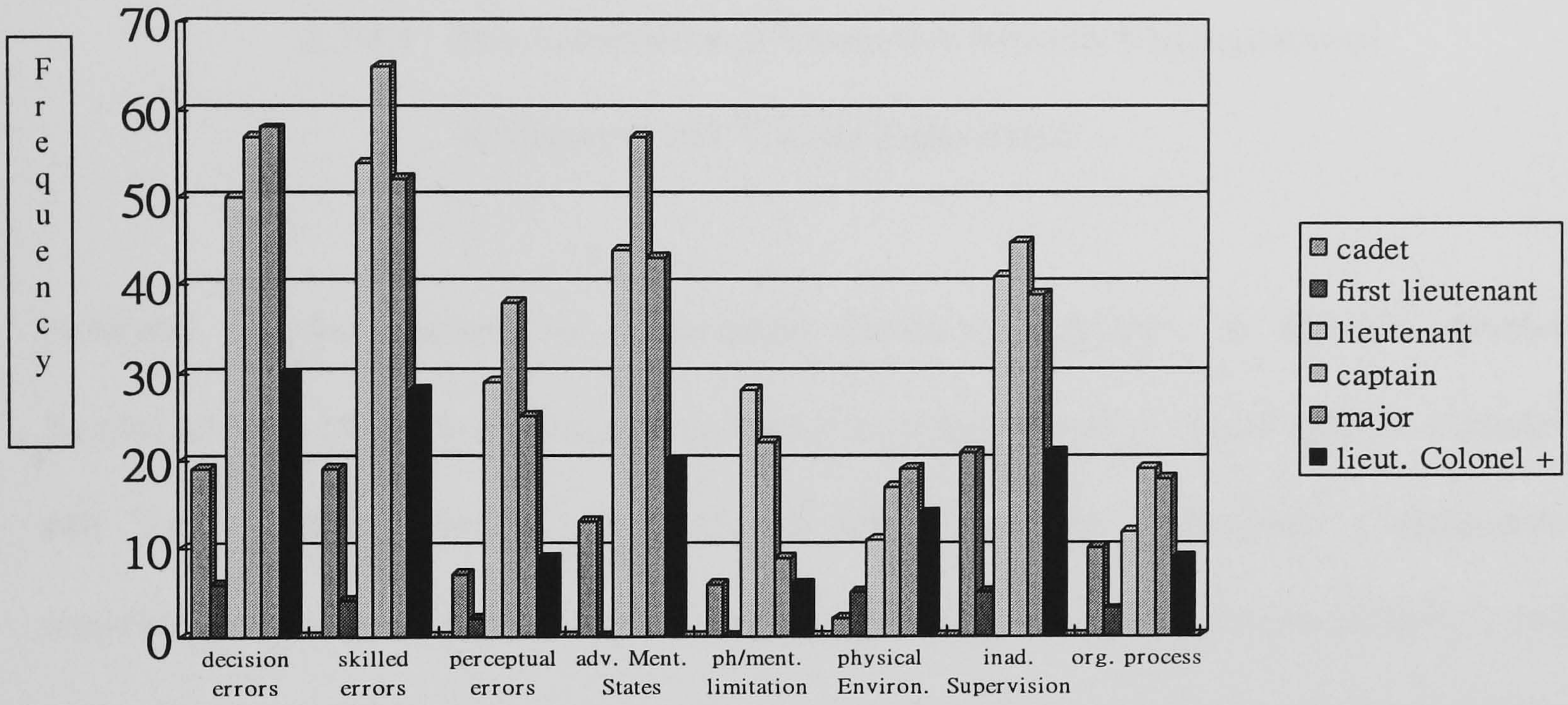


Figure 2.9 Frequency of HFACS categories versus pilot’s rank

2.3.4 Association between Categories within the HFACS Framework

Chi-square (χ^2) analyses of the cross-tabulations were used to assess the statistical strength of association between the categories in higher and lower levels of the HFACS. As there is no identifiable dependent or independent variable in a χ^2 test of association these analyses were supplemented with further analyses using Guttmann and Kruskal’s lambda (λ) which was used to calculate the proportional reduction in error (PRE). The lower level categories in the HFACS were designated as being dependent upon the categories at the immediately higher level in the framework. A positive value for

Guttmann and Kruskal's lambda indicates the strength of the directional relationship with the higher levels in the HFACS being deemed to influence (cause) changes at the lower organizational levels, thus going beyond what may be deemed a simple test of co-variance between categories.

2.3.4.1 The Association of Categories between 'Organizational Influences' and 'Unsafe Supervision'

Analysis of the strength of association between categories at HFACS level-4 'organizational influences' (including 'resource management'; 'organizational climate' and 'organizational process') and HFACS level-3 'unsafe supervision' ('inadequate supervision'; 'planned inappropriate operations'; 'failed to correct a known problem'; and 'supervisory violations') found that there were eight pairs of significant associations: 'resource management' versus 'inadequate supervision'; 'organizational climate' versus 'inadequate supervision'; 'organizational climate' versus 'failed to correct a known problem'; 'organizational climate' versus 'supervisory violations'; 'organizational process' versus 'inadequate supervision'; 'organizational process' versus 'planned inappropriate operations'; 'organizational process' versus 'failed to correct a known problem'; and 'organizational process' versus 'supervisory violations'. These relationships are summarized in table 2.2 and are described diagrammatically in figure 2.10. Further examination of the directional PRE showed two significant associations between categories at level-4 and level-3; 'organizational climate' versus 'inadequate supervision' and 'organizational process' versus 'inadequate supervision'.

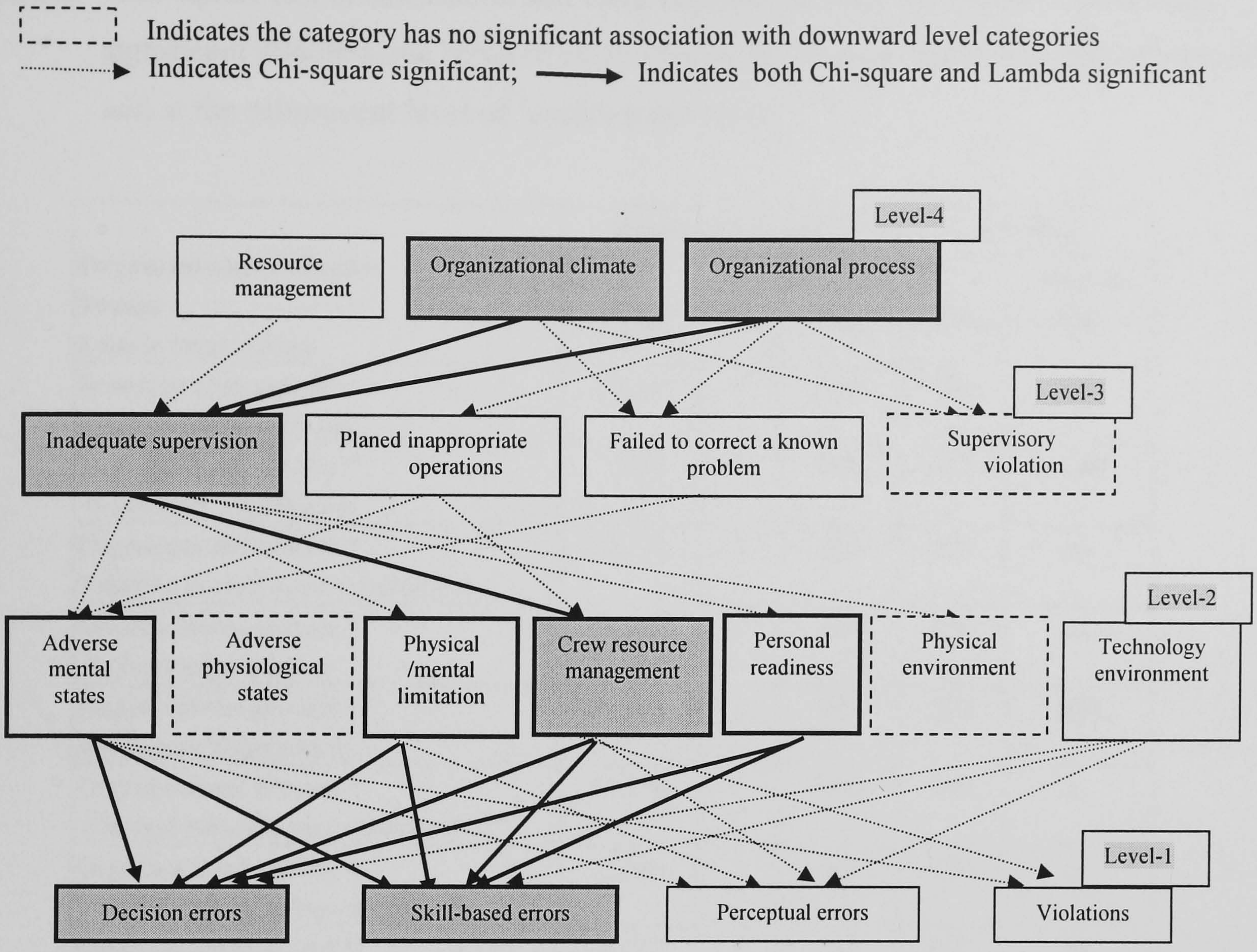


Figure 2.10 The significant association of Chi-square ($\chi 2$) and Lambda (λ) from 'organizational influences' to 'unsafe acts of operators' of HFACS framework.

Table 2.2 Chi-square test of association and Guttmann and Kruskal's Lambda summarising significant relationships between categories at the level of 'organizational influences' and at the subsequent level of 'unsafe supervision'

Organizational Influence Versus Unsafe Supervision	**Pearson Chi-square**			**Lambda**	
	Value	**Df**	**Asymp. Sig**	**Value**	**Approx Sig.**
Resource Management * Inadequate Supervision	13.525	1	.000	.000	ns
Organizational climate * Inadequate Supervision	**7.562**	**1**	**.006**	**.023**	**.045**
Organizational climate * Failed to correct a known problem	39.753	1	.000	.000	ns
Organizational climate * Supervisory violation	61.121	1	.000	.000	ns
Organizational process * Inadequate Supervision	**91.208**	**1**	**.000**	**.282**	**.000**
Organizational process * Planned inappropriate operations	14.174	1	.000	.000	ns
Organizational process * Failed to correct a known problem	11.899	1	.001	.000	ns
Organizational process * Supervisory violation	46.307	1	.000	.000	ns

ns: not significant

2.3.4.2 The Association of Categories between 'Unsafe Supervision' and 'Preconditions for Unsafe Acts'

Analysis of the strength of association between categories at HFACS level-3 'unsafe supervision' and HFACS level-2 'preconditions for unsafe acts' (including the categories of 'adverse mental states'; 'adverse physiological states'; 'physical/mental limitations'; 'crew resource management'; 'personal readiness'; 'physical environment'; and 'technology environment') showed a further eight pairs of significant associations. These were 'inadequate supervision' versus 'adverse mental states'; 'inadequate supervision' versus 'physical/mental limitations'; 'inadequate supervision' versus 'crew resource management'; 'inadequate supervision' versus 'personal readiness'; 'inadequate supervision' versus 'physical environment'; 'planned inappropriate operations' versus 'adverse mental states'; 'planned inappropriate operations' versus 'crew resource management'; and 'failed to correct a known problem' versus 'adverse mental states'. These are summarized in table 2.3 and described in figure 2.10. Further examination of the directional PRE found that there was a significant association between the level-3 and level-2 categories of 'inadequate supervision' versus 'crew resource management'.

Table 2.3 Chi-square test of association and Guttmann and Kruskal's Lambda summarising significant relationships between categories at the level of 'unsafe supervision' and at the subsequent level of 'preconditions for unsafe acts'

Unsafe Supervision Versus Preconditions for Unsafe Acts	**Pearson Chi-square**			**Lambda**	
	Value	**df**	**Asymp. Sig.**	**Value**	**Approx Sig.**
Inadequate Supervision * Adverse mental states	29.545	1	.000	.038	ns
Inadequate Supervision * Physical/mental limitation	7.945	1	.005	.000	ns
Inadequate Supervision * Crew resource management	**143.573**	**1**	**.000**	**.281**	**.002**
Inadequate Supervision * Personal readiness	10.101	1	.001	.000	ns
Inadequate Supervision * Physical environment	6.604	1	.010	.000	ns
Planned inappropriate operations *Adverse mental states	5.730	1	.020	.022	ns
Planned inappropriate operations *Crew resource management	10.824	1	.001	.027	ns
Failed to correct a known problem * Adverse mental states	6.958	1	.008	.000	ns

ns: not significant

2.3.4.3 The Association of Categories between 'Precondition for Unsafe Acts' and 'Unsafe Acts of Operators'

Analysis of the strength of association between categories at HFACS level-2 'preconditions for unsafe acts' and HFACS level-1 'unsafe acts of operators' (including the categories of decision errors; skill-based errors; perceptual errors; and violations) showed a further 16 pairs of significant associations. These were 'adverse mental states' versus 'decision errors'; 'adverse mental states' versus 'skill-based errors'; 'adverse mental states' versus 'perceptual errors'; 'adverse mental states' versus 'violations'; 'physical/mental limitations' versus 'decision errors'; 'physical/mental limitations' versus 'skill-based errors'; 'physical/mental limitations' versus 'perceptual errors'; 'crew resource management' versus 'decision errors'; 'crew resource management' versus 'skill-based errors'; 'crew resource management' versus 'perceptual errors'; 'crew resource management' versus 'violations'; 'personal readiness' versus 'decision errors'; 'personal readiness' versus 'skill-based errors'; 'technology environment' versus 'decision errors'; 'technology environment' versus 'skill-based errors'; and 'technology environment' versus 'perceptual errors'. Further examination of the directional PRE found that there were eight significant associations between the level-2 and level-1 categories of 'adverse mental states' versus 'decision errors; 'adverse mental states' versus 'skill-based errors'; 'physical/mental limitations' versus 'decision errors'; 'physical/mental limitations' versus 'skill-based errors'; 'crew resource management' versus 'decision errors'; 'crew resource management' versus 'skill-based errors'; 'personal readiness' versus 'decision errors'; and 'personal readiness' versus 'skill-based errors'. These are summarized in table 2.4 and described diagrammatically in figure 2.10.

Table 2.4 Chi-square test of association and Guttmann and Kruskal's Lambda summarising significant relationships between categories at the level of 'preconditions for unsafe acts' and at the subsequent level 'unsafe acts of operators'

Precondition for Unsafe Acts Versus Unsafe Acts of Operators	**Pearson Chi-square**			**Lambda**	
	Value	Df	Asymp. Sig.	Value	Approx Sig.
Adverse mental state * Decision errors	**59.226**	**1**	**.000**	**.269**	**.000**
Adverse mental states * Skill-based errors	**61.701**	**1**	**.000**	**.283**	**.000**
Adverse mental states * Perceptual errors	43.730	1	.000	.000	ns
Adverse mental states * Violations	13.025	1	.000	.000	ns
Physical/mental limitation * Decision errors	**50.996**	**1**	**.000**	**.211**	**.000**
Physical/mental limitation * Skill-based errors	**33.051**	**1**	**.000**	**.164**	**.000**
Physical/mental limitation * Perceptual errors	27.401	1	.000	.000	ns
Crew resource management * Decision errors	**42.578**	**1**	**.000**	**.215**	**.000**
Crew resource management * Skill-based errors	**35.423**	**1**	**.000**	**.195**	**.000**
Crew resource management * Perceptual errors	62.086	1	.000	.000	ns
Crew resource management * Violations	19.850	1	.000	.000	ns
Personal readiness * Decision errors	**10.220**	**1**	**.001**	**.058**	**.015**
Personal readiness * Skill-based errors	**15.181**	**1**	**.000**	**.075**	**.001**
Technology environment * Decision errors	3.982	1	.046	.000	ns
Technology environment * Skill-based errors	5.724	1	.017	.000	ns
Technology environment * Perceptual errors	6.982	1	.008	.000	ns

ns: not significant

2.3.5 Inter-rater Reliability of HFACS Framework

The inter-rater reliabilities assessed using Cohen's Kappa ranged between 0.440 and 0.826, a range of values spanning between moderate agreement and substantial agreement. Fourteen HFACS categories exceeded a Kappa of 0.60 which indicates substantial agreement. Four categories had Kappa values between 0.40 and 0.59 indicating moderate levels of agreement (Landis & Koch, 1977). Inter-rater reliabilities calculated as a simple percentage rate of agreement obtained reliability figures between 72.3% and 96.4%, also indicated acceptable reliability between the raters (table 2.5).

Table 2.5 The frequency and percentage of accident and inter-rater reliability of HFACS categories (ranked in terms of increasing inter-rater percentage agreement)

Categories of HFACS	**HFACS level**	**Frequency of occurrence**	**Inter-rater Reliability**	
			Cohen's Kappa	Percentage Agreement
Personal readiness	2	29	0.695	72.3%
Decision errors	1	223	0.675	81.5%
Skilled-based errors	1	226	0.712	83.4%
Violations	1	160	0.695	84.9%
Perceptual errors	1	116	0.667	85.1%
Adverse mental states	2	184	0.748	86.0%
Resource management	4	184	0.768	86.4%
Organizational process	4	76	0.593	87.4%
Inadequate supervision	3	177	0.826	89.7%
Crew resource management	2	146	0.801	89.7%
Technology environment	2	44	0.608	89.9%
Physical/mental limitation	2	73	0.691	90.4%
Physical environment	2	74	0.797	92.2%
Planned inadequate operations	3	24	0.706	94.6%
Failed correct a known problem	3	12	0.548	95.8%
Supervisory violation	3	8	0.694	96.2%
Organizational climate	4	4	0.440	96.4%
Adverse physiological states	2	2	0.441	96.4%

2.4 Discussion

2.4.1 Causal Factors of Accidents Identified in the HFACS Framework

At the level of 'unsafe acts of operators', 'skill-based errors' had the highest rate of occurrence (43.2%) in the HFACS framework, including actions such as inappropriate stick and rudder coordination, excessive use of flight controls, glide path not maintained, and adopting an improper airspeed or altitude. 'Decision errors' had the second highest rate (42.6%) including instances of selecting inappropriate strategies to perform a mission, improper in-flight planning, making an inappropriate decision to abort a take-off or landing, or using improper remedial actions in an emergency. The frequency of both 'skill-based errors' (226) and 'decision errors', (223) was very similar, comprising the majority of instances in HFACS framework. The initial training programs for cadet pilots focus almost solely on factors at the skill-based level. At the present time there are no 'decision-making' training programs in existence in the R.O.C. Air Force. Therefore, there is an urgent need to address the importance of aeronautical decision-making for military pilots.

At the level of 'preconditions for unsafe acts', 'adverse mental states' had the highest rate of implication in accidents (35.2%) including factors such as mental fatigue, stress, over-confidence, distraction, poor vigilance, or poor communication. 'Crew resource management' had the second highest rate of accidents (27.9%). Many military pilots in the R.O.C. Air Force feel that CRM is only applicable to civil aviation pilots. The findings of this investigation revealed that military aviation does need CRM but perhaps a modified version. Even pilots of single-seat fighters require good communication with their wingman to backup each other and avoid a mid-air collision. They need to follow their leader (number one) to form a tactical formation to undertake a mission and they need to exchange information with Tactical Air Traffic Control (TATC) clearly. 'Physical environment' had the third highest rate of accidents causal factors (14.1%). The majority of these accidents involved inappropriate responses to bird strikes. This research suggests that current bird strike projects need to be improved.

'Inadequate supervision' had the highest rate of accidents (33.8%) at the level of 'unsafe supervision'. It was observed that supervisors' failure to provide proper training for crew, a supervisory loss of situation awareness and untrained supervisors were the major contributors to accidents. It is suggested that there is a need for improving the training of supervisors. Moreover, if 'routine violations' at the level of 'unsafe acts of operators' were condoned at the supervisory level, it reinforces the inappropriate behaviours and attitudes of the flight crew. Therefore, supervisors must be encouraged to perform their tasks appropriately and precisely.

'Resource management' had the highest frequency of occurrence at the 'organizational influences' level. It is important to find the weak link in the 'resource management' chain and then to find appropriate remedial strategies, however it is also difficult to locate such 'latent failures' at an organizational level. This study found that the major contributors to accidents included poor pilot selection practices and flight training; poor aircraft design, and failures to correct known flaws.

Reason (1990, 1997) has suggested that there is a 'many to one' mapping of the psychological precursors of unsafe acts to the actual errors themselves, making it difficult to predict which actual errors will occur as a result of which preconditions. This research, within the context of the HFACS framework developed by Wiegmann & Shappell (1997, 2001a, 2001b, 2001c, 2003) and Shappell & Wiegmann (2001, 2003, 2004) would however suggest that there are statistically significant associations between categories at organizationally higher levels and specific accident contributory factors at lower levels, and between latent factors and the occurrence of specific errors committed by pilots.

2.4.2 HFACS Framework and Patterns of Military Aviation Mishaps

There were significant associations between some specific categories of the HFACS framework and type of aircraft, mission, stage of flight and rank of the pilot. The results showed that fighters had highest frequency of accidents (342), followed by training aircraft (111) and cargo aircraft (56). Further analysis found that the training aircraft were significantly associated with the HFACS categories of 'adverse mental states', 'personal readiness', 'inadequate supervision' and 'organizational process'. The training aircraft have the highest usage in the Air Force, hence there is time pressure for maintenance, the checking processes for airworthiness oversight, and instructor pilots may not have time to provide enough training/supervision. Training aircraft are also operated by novice pilots who may not be ready for solo flight. Cargo aircraft were significantly associated with 'CRM' issues because these types were operated by multi-crews, therefore, CRM was more relevant for these crew to perform their tasks than in a single-seat fighter. Fighters were generally under-represented in the HFACS categories. The possible explanation for this was that fighter pilots were mature pilots who performed the most demanding tasks in all-weathers, such as interception and air combat tactics. As a result, they were aware of the risks and they were experienced with a prudent attitude.

There was a significant association between missions and the HFACS framework in three categories: 'skill-based errors', 'personal readiness', and 'inadequate supervision'. Further analysis found the task of 'close pattern' was over-represented in these three categories of accidents. A possible explanation was the 'close pattern' practicing of basic take-off and landing skills was used for training novice pilots to operate the aircraft safely. As the pilots were novices with limited experience and operating skills, if the instructor pilots did not provide proper training/supervision, sending a novice solo when he was not ready or had not developed the psychomotor skills, may have resulted in the above three HFACS categories being over represented in 'close pattern' mission.

There was a significant association between flight phase and HFACS framework in six categories. At the level of 'unsafe acts of operators', 'decision errors' and 'skill-based errors' were significantly associated with 'landing'. In the landing phase, precise psychomotor skills are required to control the aircraft and occasionally instant decisions and responses are needed. At the level of 'preconditions for unsafe acts', the categories of 'adverse mental states', 'physical/mental limitation', and 'crew resource management' were significantly associated with the phase of flying in the 'operational area'. A possible explanation was that military tactical training, such as air combat tactics or low altitude tactics, places a high physical and mental demand on the pilots. Pilots needed to be aware of the cognitive demands while flying in the 'operational area'. They are required to be in a heightened mental state to allow for a quick analysis of the dynamic situation followed by swift responses while under time pressure. They also need to have good crew resource management skills to deal with emergent risks and set the priorities for safety issues. At the level of 'unsafe supervision', 'inadequate supervision' was significantly associated with 'landing'. This was perhaps due to the instructors in the mobile flight commanding centre not providing adequate supervision, providing inappropriate instruction for landing, or back seat instructor pilots failing to provide suitable training for trainees.

Pilot's rank was related to flying experience. Senior officers normally have more flying hours than junior officers. The rank of 'cadet' was significantly over-represented in the categories of 'organizational process' and 'inadequate supervision'. It was perhaps the junior cadet pilot's lack of experience and competence to deal with organizational influences that made them vulnerable. The rank of 'lieutenant' was significantly associated with 'decision errors', 'skill-based errors', 'perceptual errors', 'adverse mental states', and 'physical/mental limitations'. Pilots with the rank of 'lieutenant' were novice pilots (between 200 and 500 flying hours), and at the beginning stages of conversion from training aircraft (AT-3) to fighters (F-16/M-2000/IDF). During this conversion period, there was a tendency toward having a higher accident rate. The rank of 'lieutenant colonel (or above)' was significantly associated with 'physical environment'. The explanation for this was probably that it was only experienced pilots whom were believed to have the ability and the confidence to undertake the risky tasks in adverse weather or over difficult terrain, so the tasks in an adverse physical environment were assigned to pilots with the rank of lieutenant colonel (or above).

2.4.3 'Organizational Influences' Affecting categories at Level-3 'Unsafe Supervision'

Reason (1997) proposed that latent conditions are present in all systems and they are an inevitable part of organizational life. For example, resources are normally distributed unequally in organizations. The original decision on how to allocate resources may have been based on sound commercial arguments, but such inequities may create reliability or safety problems for someone somewhere in the system at some later point. This investigation showed that at level-4 'organizational influences', which included the categories of 'resource management' (selection, training, monetary, and equipment resources); 'organizational climate' (including chain-of-command, policies, and culture); and 'organizational process' (including operational tempo, procedures and oversight), had several significant associations with categories at level-3 'inadequate supervision'. Furthermore, when 'organizational climate' and 'organizational process' were designated as the independent variables (i.e. the organizational factors that influence subsequent behaviours in the organization) and 'inadequate supervision' was the dependent variable, the PRE was 2.3% ($p<0.045$) and 28.2% ($p<0.000$), respectively. In the current context, if personnel in the chain-of-command show poor discipline, fail to follow SOPs and do not train subordinates to cope with time pressures, the result will be an increased likelihood of 'inadequate supervision' (at level-3).

Orasanu and Connolly (1993) have suggested that decision-making occurs in an organizational context, and that the organization influences decisions directly by stipulating standard operating procedures, and indirectly through the organization's norms and culture. Reason (1990) proposed that latent conditions are present in all systems and they are an inevitable part of organizational life. For example, resources are normally distributed unequally in organizations. The original decision on how to allocate resources may have been based on sound commercial arguments but such inequities may create reliability or safety problems for someone somewhere in the system at some later point. This analysis showed that at HFACS level-4, 'organizational influences', all the categories had some association with causal factors at level-3 ('unsafe supervision'). However, the category of 'organizational process' is the key factor at this highest organizational level. Poor 'organizational processes' were associated with inadequacies in all categories at the level of 'unsafe supervision' and hence indirectly were ultimately at the root of many operational errors resulting in accidents. Well-developed 'organizational processes' that are consistently adhered to are key to all safety management systems. The commitment to safety must come from the very highest levels of the organization if it is to be successful in this respect (Reason, 1997).

Both Reason (1990) and Wiegmann & Shappell (2003) hypothesized that inappropriate decision-making by upper-level management can adversely influence the personnel and practices at the supervisory level, which in turn affects the psychological pre-conditions and hence the subsequent actions of the front-line operators. This study provides statistical support for this hypothesized relationship. For example, the ROC Air Force is a task-oriented organization and would like to put all its resources and focus its full attention on achieving operational tasks on time with little interference from weather, aircraft condition, or pilots' rest period. From the Wing Commander's level, to Squadron Leaders and down to individual pilots, all are required to cope with pressures from time and the environment. As a result, it is perhaps not too surprising that the result of this research shows that 'inadequate supervision' had a high frequency of occurrence.

2.4.4 'Unsafe Supervision' Affecting Categories at Level-2 'Preconditions for Unsafe Acts'

Both Reason (1990, 1997) and Wiegmann & Shappell (2003) suggested that inappropriate decision-making by upper-level management can directly impact upon the personnel and practices at the supervisory level, which in turn affects the psychological pre-conditions and hence the subsequent actions of the front-line operators. The first stages of this hypothesized relationship have been demonstrated empirically in the previous section.

Wojcik (1989) proposed that some conditions studied by psychologists and are reasonably well understood, such as work schedules that allow adequate sleep. However, other conditions related to management and organizational factors are more difficult to observe and quantify. At present the accident causal factors cited by investigation authorities usually, though not always, emphasize technology, the physical environment and the more immediate human factors, an emphasis partly due to the 'stop rules' of investigators when searching for accident causes (Rasmussen, 1988). The category of 'inadequate supervision' was the key factor at HFACS level-3. It had many, significant statistical associations with categories in level-2, however, there was only one significant 'causal' relationship observed, which was with the level-2 category of 'Crew Resource Management'. The failure of senior officers in a supervisory position to provide guidance and operational doctrine to pilots was associated with many forms of psychological precursor that subsequently resulted in active, operational failures. With 'inadequate supervision' as the independent variable and CRM as the dependent variable, the PRE was 28.1% ($p<0.002$). 'Inadequate supervision' also had significant associations with four other level-2 categories; 'adverse mental states'; 'physical/mental limitations'; 'personal readiness'; and 'physical environment'.

The failure of senior officers in a supervisory position to provide guidance and operational doctrine to pilots contributed to many forms of psychological precursor which subsequently resulted in active, operational failures. These shortcomings largely impacted on the people in the system, though, rather than any aspect of the technology or physical environment. There have been several tragedies in the R.O.C. Air Force where personnel at the supervisory level have provided 'inadequate supervision'. For example, a flight leader (number 1) when leading a junior pilot (number 2) crashed in a mountains area as a result of a failure to provide appropriate operational doctrine and professional training. The accident investigation found that the factors of poor crew resource management, in addition to the physical/mental limitations of the junior pilot, were contributory aspects. Junior pilots were not considered ready for such advanced training.

2.4.5 'Preconditions for Unsafe Acts' Affecting Categories at Level-1 'Unsafe Acts of Operators'

Reason (1997) suggested that human behaviour is governed by the interplay between psychological and situational factors, and the range of human actions is always limited by the local circumstances. The pre-conditions for unsafe acts are closely related to the active failures of the operators. These factors show Reason's classic 'many to one' mapping of psychological precursors to active failures in all of the level-1 categories, with the exception of 'violations' which is only closely related to two higher level categories

(CRM and adverse mental states) suggesting that a completely different mechanism is at play here.

The category of 'crew resource management' (including demonstrating a lack of teamwork or appropriate assertiveness, a failure to conduct an adequate briefing, showing poor leadership or poor communication) was the key factor at level-2. It had significant associations with all categories at level-1. Furthermore, it provided a 21.5% ($p<0.001$) PRE with the category of 'decision errors' and 19.5% ($p<0.000$) PRE with the category of 'skill-base errors'. This strongly emphasizes why military aviation needs to put more efforts on CRM training. Some pilots in the R.O.C. Air Force were of the opinion that CRM was only of benefit in civil aviation, not for single-seater fighter pilots. However, poor CRM was not only significantly associated with poor flying skills but was also significantly associated with poor decision-making. For example, there have been several mid-air crashes where the accident investigation concluded that poor communication and teamwork among pilots and ATC reduced situational awareness. As a result, pilots made inappropriate decisions and committed operational skill-based errors resulting in these catastrophes.

The category of 'adverse mental states' (including loss situational awareness, stress, overconfidence, task saturation, distraction, and mental fatigue) also had significant associations with all categories at level-1, and could provide a 26.9% ($p<0.000$) PRE to the category of 'decision errors' and 28.3% ($p<0.000$) PRE to the category of 'skill-based errors'. Pilots in a poor mental condition were more likely to be associated with skill and decision-making errors. Moreover, the categories of 'physical/mental limitation' and 'personal readiness' both had significant associations with 'decision errors' and 'skill-based errors' at level-1 (table 3). A pilot in a poor physical or mental condition is not well prepared for duty. This significantly affects their psychomotor skill performance and decision-making in the cockpit. This is the reason why military pilots are normally strictly required to undertake periodic physical checks and are prohibited from self-medication and also why pilots undergo frequent evaluation regarding operational theories (SOPs) and flight performance (psychomotor) skills on the simulator.

Some aspects, however, are almost out of the control of even the higher levels of the organization. It is interesting to note that the level-2 category of the 'technological environment' (which is essentially concerned with such factors as the quality of cockpit interfaces) is not at all influenced by the higher managerial levels. However, it has a significant association with several HFACS level-1 categories. This is probably a result of the higher levels in the ROC Air Force chain of command having little or no influence on the cockpit design of their aircraft. Indeed, it is often the case in the military that those responsible for the design and/or procurement of large pieces of equipment are in entirely different organizations to the operators of these systems. Those responsible for the technology environment are not actually in the same management hierarchy as the people using it.

2.4.6 Reliability of HFACS

From the Cohen's Kappa results, the HFACS framework was found to have an acceptable level of agreement between the raters coding the data. However, the indexes of reliability using Cohen's Kappa and percentage of agreement between raters were occasionally discrepant in some categories. For example, 'organizational climate' had the lowest of

Kappa coefficient (0.440) but had the highest percentage agreement (96.4%). 'Adverse physiological states' had second lowest coefficient of Kappa (0.441) but had a high percentage agreement (also 96.4%), and 'failed to correct a known problem' had a low coefficient of Kappa (0.548) but also had a high percentage agreement (95.8%). The explanation for this is two fold. These HFACS categories had very low frequencies of only four, two and 12, respectively. These low frequencies are unreliable and can easily distort the Cohen's Kappa value in such instances, actually deflating its value where there is actually a very high level of agreement. Cohen's Kappa also becomes unreliable when the vast majority of observations fall into just one of the categories and there is also a high percentage of agreement between raters in this category. In this instance there is a high percentage agreement between the raters while simultaneously the value of Cohen's Kappa is low, as the latter is based upon expected probabilities based upon the marginal observed totals (Huddlestone, 2003).

Certain categories of accident causal factors in the HFACS were found to have lower reliabilities than other categories. Harris (1995) noted that certain categories of causal factor in the post-hoc coding of incident data were less likely to be reliably categorized by two independent raters than were others. The categories least likely to show high levels of reliability were those that required a great deal of inference (on the part of the assessors) when coding the data, and which also dealt with more abstract concepts, such as inferring a lack of situational awareness. It is notable that from the data in table 2.5, that with the exception of 'personal readiness', all categories at level-1 in the HFACS system show the poorest levels of inter-rater reliability. The pre-cursors of these actions (level-2) and causal factors at the level of 'unsafe supervision' (level-3), however, showed much higher levels of inter-judge reliability.

Wiegmann and Shappell (2001a) found that HFACS framework as a whole had an inter-rater reliability figure, calculated using Cohen's Kappa, of 0.71, which indicated substantial agreement. This research found that coefficient Kappa generally indicated high reliability across the majority of individual categories in the framework when applied to R.O.C. Air Force accidents, but that the categories in level-1 were consistently the factors showing low inter-rater reliability.

2.4.7 Factors Affecting Pilots' Decision-making

The importance of aeronautical decision-making (ADM) has been recognized as critical to the safe operation of aircraft, as well as accident avoidance (Jensen & Hunter, 2002). Dekker (2001a) suggested that human errors are systemically connected to the tools, tasks, operational and organizational environment of operators. It is important to clarify the role of decision errors in pilot's tools, tasks, experience, and operating environment in military aviation in order to develop effective ADM training programs for military pilots. It was found that pilots with the rank of 'cadet' (experience) flying 'training aircraft' (tools) practicing 'close pattern' (missions) during the 'landing phase' (an aspect of the working environment) were most likely to be involved in an accident. 'Decision-errors' also had a significant association with the landing phase in pilots with the rank of lieutenant. However, there are many factors at the upper levels of the HFACS framework that also indirectly affect pilots making decisions. It is important to understand that junior pilots are very vulnerable to the decisions and supervisory practices of senior management.

The category of 'decision-errors' has a significant association with flight phase and rank. However, it is important to keep in mind that the higher levels affect the next downward level in HFACS framework (figure 2.6). This means that decision errors may be affected by 'preconditions for unsafe acts', 'unsafe supervisory', or 'organizational influences'. This is particularly true of the category of 'unsafe supervision' at level-3 of the HFACS. This is one of the key factors, for it not only influences the 'decision errors' of pilots, but it also has a significant association with the type of aircraft, mission, flight phase, and rank of pilots. To precisely identify ADM training needs, it is necessary to look further into the factors underlying decision errors.

2.5 Summary

This investigation has demonstrated that the HFACS framework originally developed for analysis of US military aviation mishaps, can also be used to analyze accident data from the R.O.C. Air Force. The large sample of accident and incidents in the present study has allowed an extensive and statistically stable analysis of the inter-relationships between the categories and levels in the HFACS providing empirical evidence to support its theoretical structure. The HFACS framework has proved to be a useful tool for accident investigation and it has acceptable inter-rater reliability at the level of individual categories.

There are statistically significant associations between causal factors at higher organizational levels, the psychological contributory factors and the errors committed by pilots using HFACS. However, some care needs to be taken when interpreting the statistical relationships presented within HFACS. In a few categories, the frequency counts are small. Furthermore, the frequency counts within categories were all derived from accidents. It is unknown (and unknowable) how often instances within the various HFACS categories have occurred in day-to-day operations that have not resulted in an accident. Thus, the relationships between HFACS levels and categories should not be interpreted outside the accident causal sequence. It should also be noted that only in those cases where a significant χ^2 test of association is accompanied by a significant value for lambda can it be assumed that the categories in the lower levels of the HFACS were dependent upon the higher-level categories, as is congruent with the underpinning theory.

To improve aviation safety, the precise identification of human errors in accidents and the pinpointing of human factors problems to develop effective prevention strategies are imperative. This study also begins to provide an understanding, based upon empirical evidence, of how actions and decisions at higher levels in the organization promulgate throughout the R.O.C. Air Force to result in operational errors and accidents. This has not previously been done with data analyzed using HFACS. There are clearly defined, statistically-described paths that relate errors at level-1 (the operational level) with inadequacies at both the immediately adjacent and more remote levels in the organization. 'Decision errors' are associated with a very high percentage (42.6%) of aircrew-related accidents. These also have an intimate relationship with 'crew resource management' (level-2), and subsequently with 'inadequate supervision' (level-3) and 'organizational climate' and 'organizational process' (level-4) in this research. This research draws a clear picture that supports Reason's (1990) model of active failure and latent conditions in the organization (upon which the HFACS framework is based). Fallible decisions of upper-level command can directly affect the middle level of supervisory practices, creating 'preconditions for unsafe acts' and the impaired performance of pilots, leading to accidents. The HFACS framework can provide both a theoretical and practical foundation for describing the multiple components that are required for effective accident investigation and help to identify the training needs to remedy these weaknesses and develop effective accident prevention strategies.

Connolly, Blackwell & Lester (1989) suggested that pilot's decision-making skills could be significantly improved through the use of judgment training materials along with simulator practice. There is a need for military pilots to undergo decision-making training to improve aviation safety. However, if such a training program is to be maximally effective the most appropriate decision making strategy for each decision-making scenario has to be identified. There are a number of strategies (often embodied in mnemonics or acronyms) developed by aviation researchers and used by pilots to guide and structure in-flight decision-making. The common aim of these techniques is to form a systematic approach to decision-making that should be less affected by the human nature and should also reduce the cognitive work for pilots (O'Hare, 2003). Therefore, there is a need for evaluating the suitability of these different ADM mnemonics in different decision-making scenarios for developing an effective training program for military pilots under time pressure and high stakes tactical environment. This is the objective of the following study.

CHAPTER III

An Empirical Research for the Suitability of ADM Training Mnemonics in Tactical Environments

3.1 Introduction

From 1996 to 2000, the Republic of China (R.O.C.) Air Force converted from the Lockheed F-104 to a series of new generation fighters including General Dynamics F-16, Mirage 2000-5 and the self-developed IDF. To help ensure the safety of flight operation, R.O.C. Air Force Headquarters investigates the pattern of mishaps annually. The results of accident investigations showed that errors of judgment and poor in-flight decision-making were commonly reported. Pilots' decision errors were involved in 42.6% of accidents between 1978 and 2002 (Li & Harris, 2005b; see study I). However it has also been observed that pilots continue to make poor decisions irrespective of their flying experience or knowledge (O'Hare, 1992).

Decision making performance in the aviation domain is a joint function of the features of the tasks and the pilots' knowledge and experience relevant to those tasks. In addition to carrying out tactical missions and flying the aircraft, military pilots have to solve unexpected and ill-defined problems often, with only incomplete information available and while under time pressure (Orasanu & Connolly, 1993). Diehl (1991a) found that decision errors contributed to 56% of accidents in airlines and 53% of accidents in military aviation between 1987 and 1989. Shappell and Wiegmann (2004) found that decision errors contributed to 45% of accidents in the USAF, and 55% in the US Navy.

In recent years, the focus on human error in aviation accidents has shifted away from skill deficiencies and toward decision-making, attitudes, supervisory factors and organizational culture as the primary factors (Diehl, 1991b; Jensen, 1997; & Klein, 2000). As aircraft have become increasingly more reliable, human performance has played a proportionately increasing role in the causation of accidents. This has resulted in a proliferation of human error frameworks and accident investigation schemes (e.g. Diehl, 1989; Feggetter, 1991; Harle; 1995; Hollnagel, 1998; Hunter & Baker, 2000; Wiegmann & Shappell, 2003).

Orasanu and Connolly (1993) have suggested that much decision-making occurs in an organizational context, and that the organization influences decisions directly by stipulating standard operating procedures, and indirectly, through the organization's norms and culture. Maurino et al. (1995) suggested that it is important to understand how decisions made by people at the sharp-end (pilots) are influenced by the actions of the people at the blunt-end of their operating worlds, the higher managerial levels in their organizations. However, there is little empirical work formally describing the relationship between organizational structures, psychological pre-cursors of accidents and the actual errors committed by pilots. Decision-making is a complex cognitive process and is affected by situational and environmental conditions (Payne, Bettman, & Johnson, 1988). One of the factors that negatively influences pilot's decision-making is psychological stress. Keinan (1987) found that under stress the range of alternatives and dimensions that are considered during the decision-making process is significantly restricted compared with normal conditions.

3.1.1 Decision-making in Aviation Operations

For over 25 years the importance of aeronautical decision-making has been recognized as critical to the safe operation of aircraft. Jensen & Benel (1977) reported that 51% of fatal general aviation accidents from 1970 through 1974 were associated with decision errors. More recent studies (Wiegmann & Shappell, 2004) have also found decision errors to be a major factor in aviation accidents. Orasanu and Fisher (1997) investigated the five highest performance pilots and the five lowest performance pilots, and found a tendency for high performance pilots to use low workload situations to make plans and collect more relevant information when compared with the poorer performing pilots. High performance pilots also demonstrated greater situation awareness. The key issues of pilot's decision-making are time pressure and risk. However, Mjos (2001) suggested that in emergent situations, uncertainty might outweigh time pressure as the key stressor bearing on the decision-making strategy.

Aviation environments are often complex and different factors such as problem patterns, aircraft types, missions, available time, or risk may influence pilots' in-flight decision-making. Aeronautical knowledge, skill, and judgment have always been regarded as the three basic faculties that pilots must possess (Diehl, 1991b). The requisite knowledge and skills have been imparted in academic and flight training programs and have subsequently been evaluated as part of the pilot certification process. In contrast, ADM has usually been considered to be a trait that good pilots innately possess or an ability that is acquired as a by-product of flying experience (Buch & Diehl, 1984). Means, Salas Crandall and Jacobs (1993) pointed out that when pilots are under stress the likelihood of making serious errors increases and they are more likely to ignore relevant information, make more risky decisions and perform with less skill. However, Zakay (1993) found that practice without time pressure did not enhance decision making under time constraints, and suggested that if decision making is likely to be required under time pressure or other stressful conditions, practice should also include task performance under those conditions.

Military pilots frequently make important decisions and these may have very serious consequences. Some decisions are made with ambiguous information, in hostile environments, and with very little time available. A critical component of pilot proficiency is the ability to make good decisions. Decision skills might be trainable (Kaempf & Orasanu, 1997). The early concepts of pilot decision-making were based on models that reflected the level of thinking in cognitive psychology. These models remain the underlying premise of many contemporary decision training programs in aviation (Kaempf & Klein, 1994). The research paradigm of naturalistic decision-making (NDM) has provided an alternative approach for understanding how pilots make decisions and for designing training interventions that will help pilots when making decisions under uncertain, high pressure, high stakes, and in time-limited situations (Beach & Lipshitz, 1993; Cohen, 1993; David, 1997; Drillings & Serfaty, 1997; Endsley, 1993; Jensen, 1997; Jensen, Guilke & Tigner, 1997; Jensen & Hunter, 2002; Kaempf & Orasanu, 1997; Klein, 1993a; Klein & Woods, 1993; Orasanu & Salas, 1993; Stokes, Kemper & Kite, 1997).

3.1.2 Classical Decision-making and Naturalistic Decision-making in Aviation Domain

There are two contrasting paradigms for the study of decision-making. Classical decision theory has focused on normative models, frequently derived from economic theories relevant to a management context. Naturalistic decision-making research has investigated the cognitive processes that underlie how individuals actually make decisions in real world situations and how they use their experience and training under demanding conditions (Orasanu, 1991; Zsambok, 1997). Classical decision-making (CDM) theory has focused on normative model. In general, normative models are well suited to teach novices rational decision strategies, in order to prepare them for development of professional know-how and skill. However, for proper design of tools to support expert decision making, understanding the nature of expert skill and decision strategies is necessary (Rasmussen, 1993).

Klein (1988) observed that decision makers in difficult situations and under time stress did not appear to use the classical decision-making strategies to make decisions, even when they were trained in that approach. There are two major approaches within CDM, the 'preference and choice' approach and 'statistical inference' approach. However, the CDM paradigm was criticised as being a poor description of decision-making on the flight deck (Duggan & Harris, 2001). However, in contrast to naturalistic decision making, classical decision theories have not paid much attention to the role of expertise (Klein, 1993). Despite the recognized need, the military has no formal programs to teach its pilots how to make decision. The shortfall of the accepted classical decision training practices is that they communicate relatively simple, prescript decision formulas based on classical approaches. These strategies address one type of decision and do not address issues concerning situation awareness (Kaempf & Orasanu, 1997).

Naturalistic decision-making (NDM) is the study of how people use their experience to make decisions in a field setting (Zsambok & Klein, 1997). The field of naturalistic decision making (NDM) has some of its roots in the military's need to better understand the human dimensions of command and control. Naturalistic decision-making research has investigated the cognitive processes that underlie how individuals actually make decisions and how they use their experience and training under demanding conditions. Experience affects decision making by improving the ease and accuracy of situation assessment, by increasing the quality of the courses of action considered by the decision maker, and by enabling the decision maker to construct and use a mental simulation (Klien, 1993). O'Hare (1992) proposed that naturalistic decision-making does indeed follow rather different paths to classical decision-making. There is evidence that the pattern-recognition processes play a significant role in decision-making in naturalistic situation. In fact, considerable aeronautical training is devoted to establishing connections between patterns of cues and appropriate responses. When a significant threat to the likelihood of achieving a goal is perceived and no immediately applicable procedures exist, then a more deliberative mode of activity is required. Naturalistic decision-making is characterized by 'dynamic and continually changing conditions, real-time reactions to these changes, ill-defined tasks, time-pressure, significant consequences for mistakes' (Klein & Klinger, 1991). All these characteristics are also associated with ADM, so the results of naturalistic decision-making studies should generate useful insights into the process of ADM.

3.1.3 Decision-making Theories in Aviation

In an emergency decisions are often made under conditions of some uncertainty and emergency in the aviation domain. Sometimes, decisions that are made carefully and logically do not achieve the expected outcome as the aviation environment is a continually changing in the dynamic situation. Psychologists make distinctions between models of decision-making that describe what it is that people do when they engage in a cognitive task and what people ought to do to be an effective decision maker (Galotti, 2002). Some aspects of the field of naturalistic decision-making (NDM) have potential to help researchers understand better the human dimensions of decisions in the aviation environment.

3.1.3.1 Recognition-primed Decisions

Klein (1997) observed that a decision maker does not directly compare alternatives and stop generating alternative options when a satisfactory decision is found. The focus is on understanding the situation and judging its familiarity, not on the generation of options to find the solution. There are four important aspects of situation assessment in the decision-making process; plausible goals, relevant cues, expectancies, and identifying the typical actions to take. Klein (2000) found that a decision maker rarely considered multiple options but works sequentially from the most plausible option. If a strategy has been found as being unsuitable, the next most plausible option would be selected. Decision makers use their previous experience to frame the current situation. When a pilot finds a good match between the current situation and past experience, then the course of action will be generated according to their previous experience.

The Recognition-Primed Decision (RPD) Model (Figure 3.1) proposed by Klein (1993a) postulates that experienced decision makers generate fewer alternatives for action. The simplest decision-making is where the decision maker is confronted by a situation that is recognized and the obvious solution is implemented. A more complex case is where the decision maker performs some conscious evaluation of the solution, typically using imagery to uncover problems prior to carrying it out. The most complex case is where the decision maker evaluates the situation and finds his solution requires modification, or the option is judged inadequate and rejected.

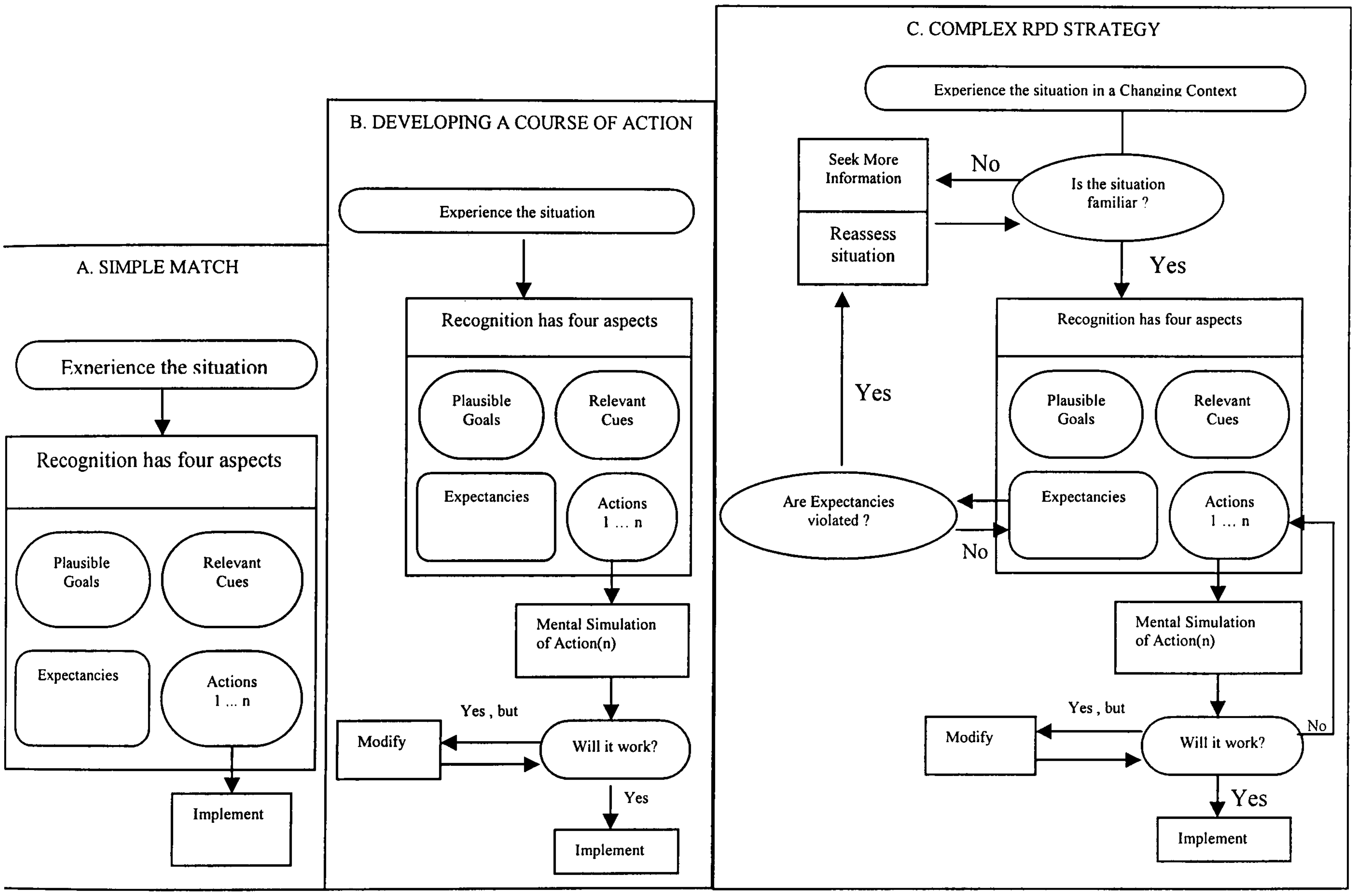


Figure 3.1 Recognition-primed decision model

(From *A Recognition-Primed Decision Model of Rapid Decision Making*, Klein, 1993a)

3.1.3.2 Recognition/Meta-cognition Decision Making Model

The Recognition/Metacognition (R/M) decision-making model proposed by Cohen, Freeman and Thompson (1995) explains how experienced decision makers are able to exploit their experience in a domain and at the same time handle uncertainty and novelty. They construct and manipulate concrete, visual models of the situation, not abstract aggregations. Uncertainty is represented explicitly at the metacognitive level, in terms of incompleteness, conflict, and unreliability. Critical thinking is not always appropriate. The decision maker usually acts immediately unless the risk of delay is acceptable, the cost of an error is high, or the situation is unfamiliar or problematic in some way. Inexperienced decision makers do not carefully assess how much time they have before they must commit themselves. More experienced decision makers spend more time on decision making by considering the particulars of the situation more fully.

According to Cohen, Freeman & Thompson (1995), the integration of observations into situation models and plans often occurs under the influence of metacognitive control (Figure 3.2). Meta-recognitional processes include; (a) identification of evidence-conclusion within the evolving situation model and plan; (b) the process of critiquing identifies problems in the evidence-conclusion that support the situation model or plan; (c) the processes of correcting the response to these problems; and (d) a high-level process called the 'quick test' which controls the critiquing and correcting process. To reflect the complementary roles of recognition and metacognition in decision-making, this framework is called the Recognition/Metacognition model.

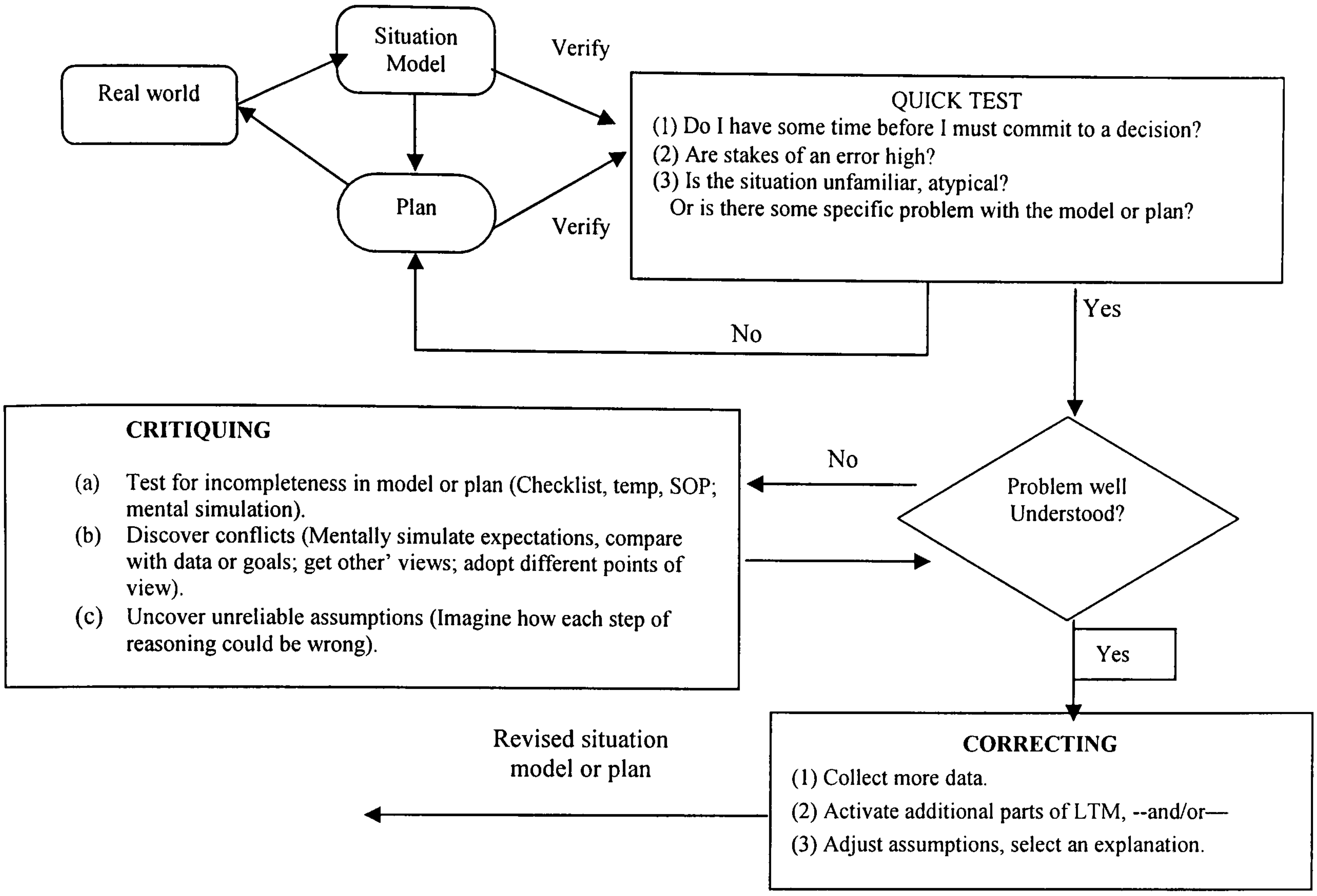


Figure 3.2 Recognition/Metacognition model of decision-making

(From *Training Metacognitive Skills for Decision-making*, by Cohen, Jared, Freeman & Thompson, 1995)

3.1.3.3 ARTFUL Decision Making

The ARTFUL decision-making model (Figure 3.3) is consistent with the broad range of evidence on human performance proposed by O'Hare (1992). Once a goal is adopted, behavior directed toward that goal continues unless it is interrupted. The principal ongoing activity of the decision maker is to monitor the information presented by the system and to interpret the information as either normal or abnormal. The proposed ARTFUL model consists of a goal-directed process with five components which are situation awareness; risk assessment; planning; response selection; and response execution. Goal setting is at the apex of the model, with reciprocal connections to the processes of situation awareness and planning (O'Hare, 2003). The acronym ARTFUL indicates these steps and its processes, including Awareness (as a result of monitoring); Risk (assessing the risks of current and alternative courses of action); Time (the critical factor in decision making in dynamic environments; and Further options (whether the decision maker can generate alternative options). In dynamic systems, positive checking is required to initiate changes in goals. Concentrating on diagnosis can result in failures of planning because there is a limited supply of attentional resources which are consumed by the activities involved in maintaining situational awareness. In difficult situations, novices will be required to invest more resources in detection and diagnosis and will exhibit greater deficiencies in planning (O'Hare, 1992).

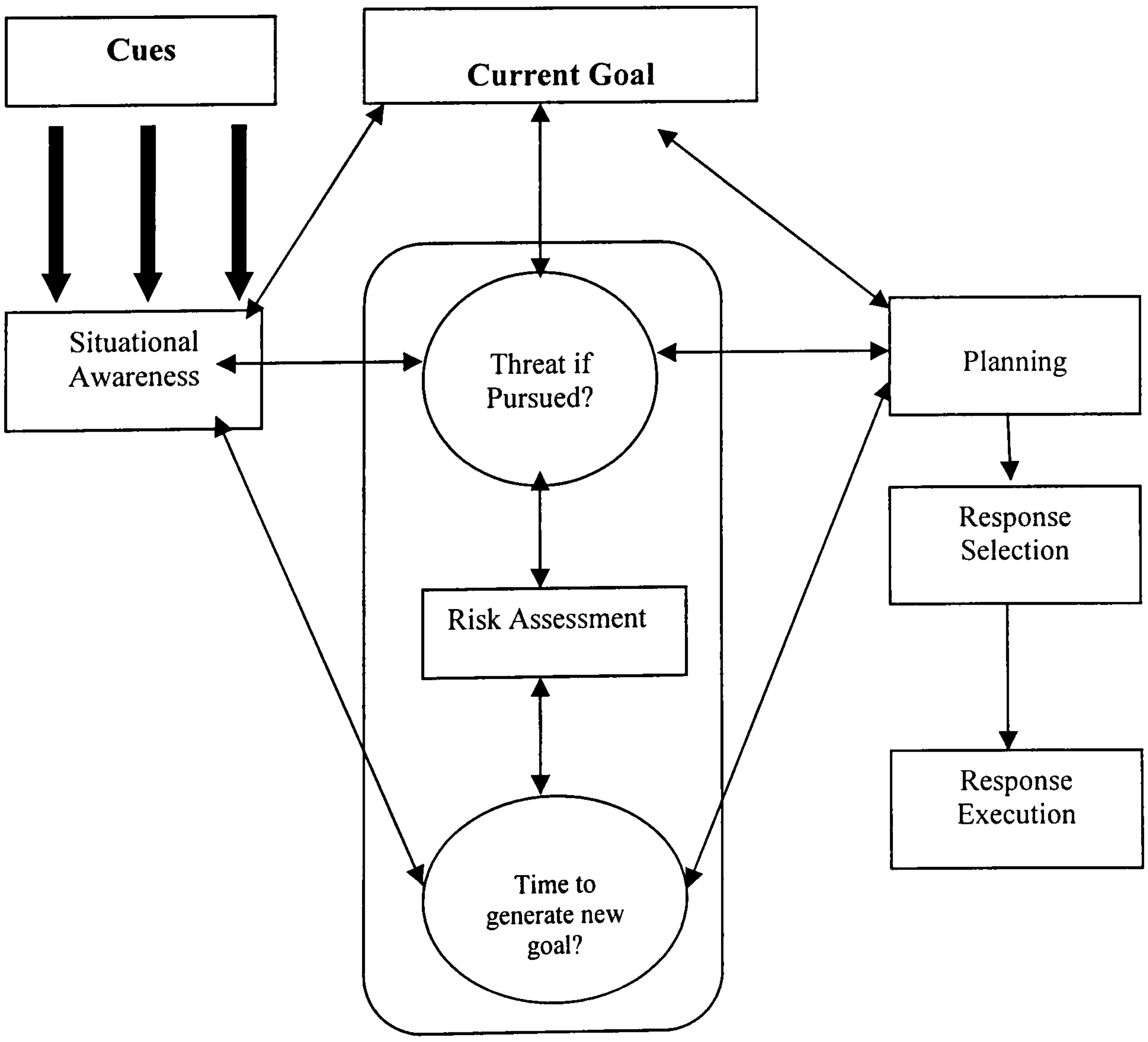


Figure 3.3 ARTFUL model of aeronautical decision-making

(From *The ARTFUL Decision Maker: A Framework Model for Aeronautical Decision Making*, O'Hare, 1992)

3.1.3.4 Conflict Theory Decision Making Model

The conflict-theory model of Janis and Mann (1977) follows a logical progression. Inaction at any step will lead to defective coping if the danger materializes, whereas effective coping can only occur through vigilant action (Figure 3.4). The aim is to understand the true situation (situation awareness) in order to look for solutions at that critical point, and to prevent the decision-making process from deteriorating. Among the models presented, the conflict-theory model appears to offer practical guidance to pilots (Murray, 1997). Military pilots are task-oriented and are predisposed to undertake difficult flights, to meet schedules, and to complete a mission as planned. Pilots probably believe, intuitively, that most of their flying decisions are arrived at logically, with due care and consideration.

Military pilots must be able to focus attention on the most important task at hand but also be able to shift the focus of their attention when priorities change, as they are constantly facing challenges to their attention in many forms, including time pressure, goal conflicts, and physical requirements. In Janis and Mann's formulation a good decision-making process (vigilant decision maker) is one in which the decision maker successfully accomplishes a series of tasks involving the collection of information about a wide range of alternatives; the careful assessment of the risks and benefits of each course of action; and the preparation of contingency plans for dealing with the known risks. If cues are detected and diagnosed as indicating some potential threat to the attainment of their active goal, then the key question becomes whether or not sufficient time is available to search for alternative options.

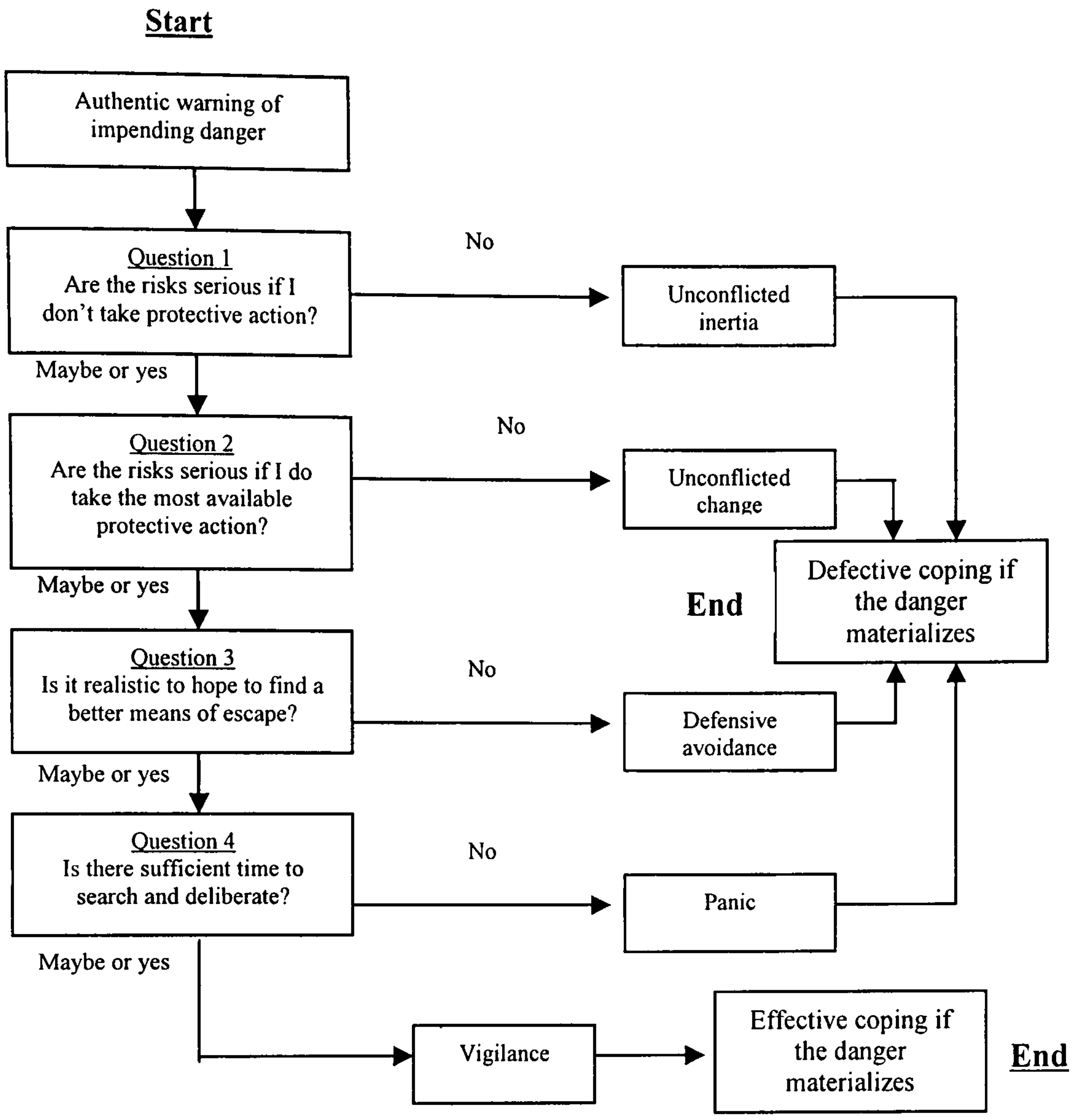


Figure 3.4 Conflict-theory decision-making model

(From *A Psychological Analysis of Conflict, Choice, and Commitment*, by Janis & Mann, 1977)

3.1.3.5 Decision Process Model

The decision process model (figure 3.5) draws on Klein's (1993a) RPD model and Wickens and Flach's (1988) information-processing model (Orasanu & Fischer, 1997). The model consists of two major components, situation assessment and choosing a course of action. Situation assessment requires the definition of the problem and assessment of risk level and available time to make the decision. Available time is the major factor for selecting subsequent strategies. If the situation confronted is not understood, diagnostic actions may be taken, but only if there is enough time to do so. If risk is high and time is limited, action may be taken without a thorough understanding of the problem.

Certain diagnostic actions serve a dual purpose. The actions could solve the problem as well as provide diagnostic information about the nature of the problem. Selecting a suitable course of action depends on the affordances of the situation. In order to deal appropriately with the situation, the decision maker must be aware of what response options are available and what constitutes an appropriate process, such as evaluating an option, choosing, scheduling, or inventing an action.

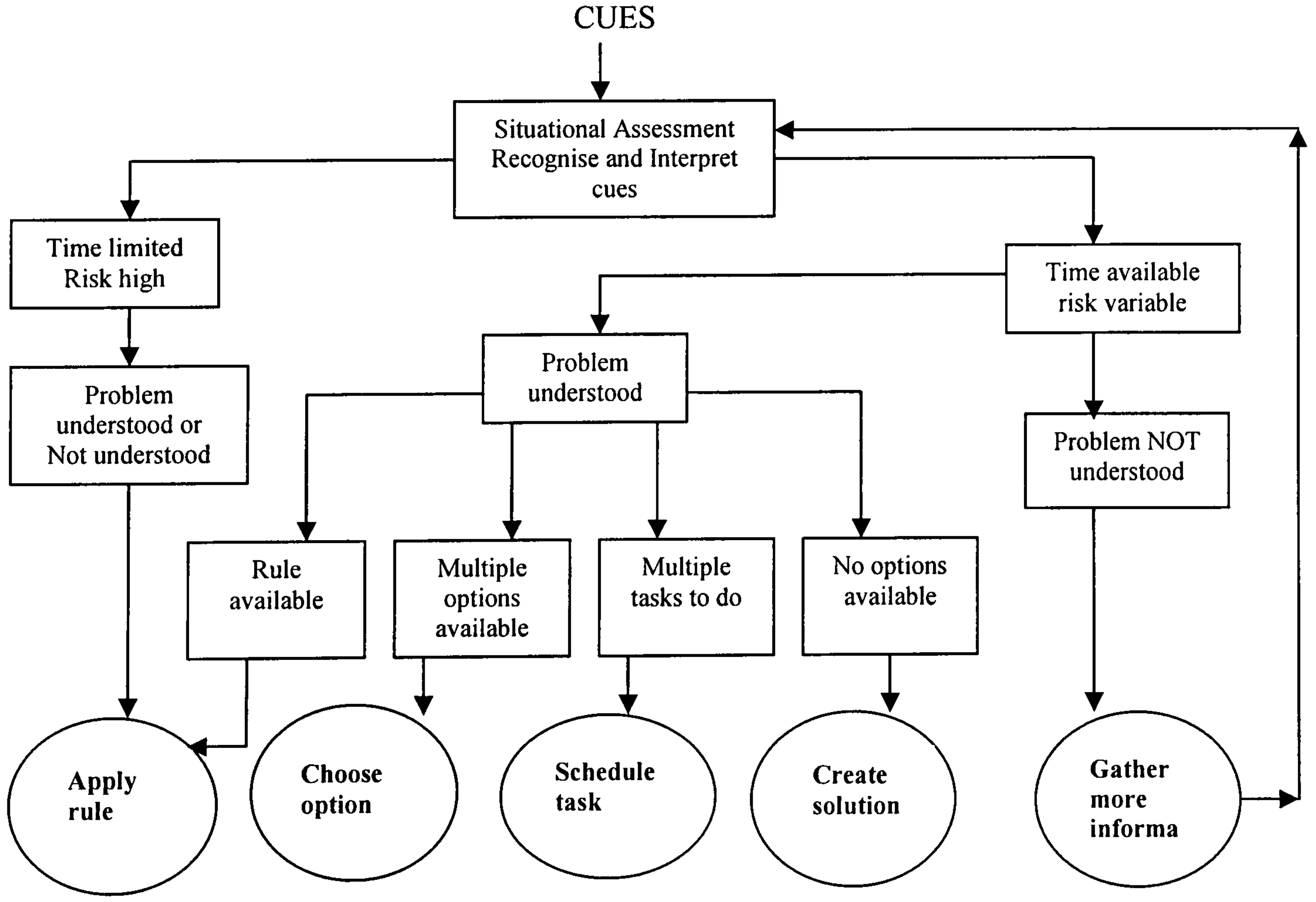


Figure 3.5 Decision process model

(From *Finding Decisions in Natural Environments: The View from the Cockpit*, by Orasanu & Fischer, 1997)

3.1.4 Situation Awareness and Decision-making

Aviation psychologists working in the area of situation awareness have made a clear differentiation between situation awareness (SA) as a state of the individual, and situation assessment as the process by which the state of awareness is achieved (Sarter & Woods, 1991). Endsley (1995c) developed a model of situation awareness based on an information-processing model. Endsley (1997) defines situation awareness as 'the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the future'. This model suggests that situation assessment begins with goal specification and includes (1) perceiving the status, dynamics, and attributes of relevant elements; (2) understanding what is perceived; and (3) using that information to project the future states of the elements. A model of situation awareness and its importance in decision making has been proposed by Endsley (1997) and is presented in Figure 3.6.

Kaempf & Orasanu (1997) suggested that many decisions made by flight crews are procedural and emphasized the importance of situation assessments. Endsley & Bolstad (1994) suggested that in novel situations, decision makers may be forced to use analytic processes that stress limited internal resources. With increasing experience, decision-makers may be able to draw upon mental models and schemata of prototypical situations to provide high levels of situation understanding and hence make good decisions without overloading attention and working memory constraints.

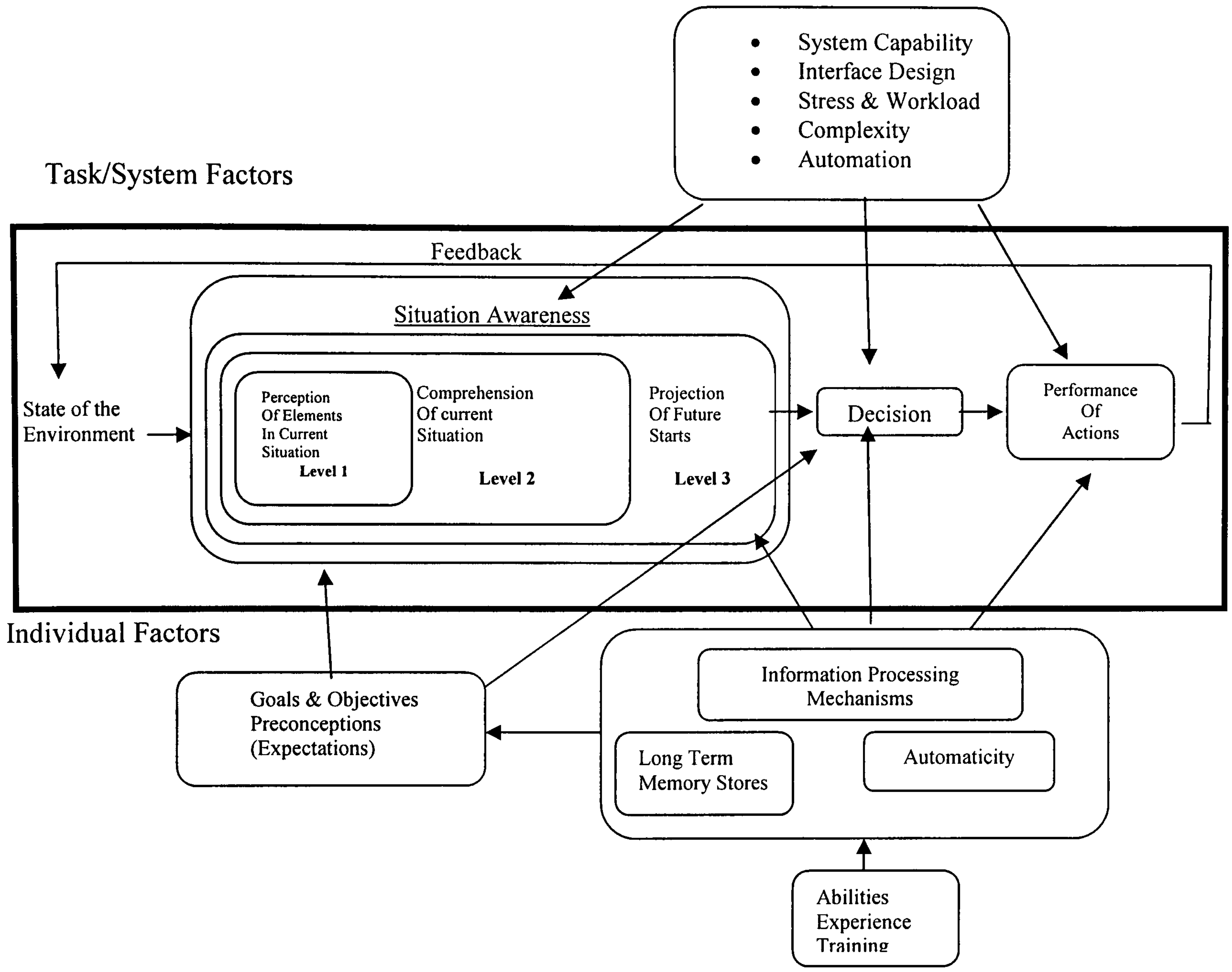


Figure 3.6 Model of situation awareness in dynamic decision-making

(From *The Role of Situation Awareness in Naturalistic Decision Making*, by Endsley, 1997)

Beringer & Hancock (1989) suggested that operating advanced aircraft has made increasing demands on pilot's cognitive abilities as the complexity of systems has imposed an increasing information load. In aviation operations, the limited data collection, integration, and response capability of the pilot will be challenged. In the dynamic flight environment, effective decision-making is highly dependent on situation awareness. Endsley & Bolstad (1994) suggested that situation awareness and decision-making are indispensable for flight safety and are closely related. The most significant aspect of decision-making is situation assessment. This is a precursor for situation awareness, which itself is the precursor for all tasks of decision-making (Lipshitz, 1993; Nobel, 1993).

Lipshitz (1993) compared nine models of decision-making and found situation assessment to be a central element in all nine. He defined situation assessment as a sizing up and construction of a mental picture of the situation and reported that its contribution to decision making was necessary for (1) action selection or (2) the initiation of alternative evaluations. Typical appropriate actions are identified by the decision maker's experience, and accuracy of assessment is determined by comparing new information with expectation. Noble (1993) developed a decision model in which the role of situation assessment is centralized and conceptualized situation assessment as including (1) interpretation of the meaning of a situation, (2) inference about the underlying causes, (3) assessment of risks, and (4) identification of the actions required.

By analyzing crewmembers' actions in realistic scenarios, Orasanu (1995) divided decision making into situation assessment and action choice, and described situation assessment as including diagnostic skills for causal reasoning, hypothesis generation and testing. Orasanu, Davison & Fischer (2001) pointed out that situation awareness is the starting point for pilot's decision making in abnormal and emergency situations, as the pilot cannot solve a problem unless (1) the pilot recognizes that they have a problem and (2) the pilot understands the nature of the problem. Situation awareness is most critical to pilots' decision-making when conditions are changing rapidly and demand frequent updating.

3.1.5 Risk Management and Decision-making

For military pilots operating in a hostile environment, the normal hazards of aviation are compounded by the enemy's intent for the destruction of their aircraft. Jensen, Guilke & Tigner (1997) suggested that risk management should be a key part of the decision-making process. Orasanu, Davison & Fischer (2001) recommended that to manage threats, pilots must first assess the risks associated with them. Risk assessment feeds into decision making in two ways: during the assessment of the precipitating threats and in evaluating potential courses of action. Janis and Mann (1977) proposed that a good decision-making process is one in which the decision maker successfully accomplishes a series of tasks involving the collection of information about a wide range of alternatives, the careful assessment of the risks and benefits of each course of action, and the preparation of contingency plans for dealing with known risks. Slovic (1987) observed that risk perception depends on the experience people have with a situation; their personal vulnerability; the level of control they have over a situation; and the time frame.

Two factors combine to determine how significant a loss is: the probability of the loss and the magnitude of the loss (Yates & Stone, 1992). Thomas (2003) suggested that in a military organization involved in high-risk operations there is the explicit understanding that safe and efficient performance is dependent upon the effective training of personnel. Soeters & Boer (2000) indicated that the precise following of rules is a matter of life and death in military aviation. A large part of aviation training focuses on learning to follow procedures and regulations. Previous training, extensive regulations, and flight preparation for all aspects of a flight limit the risks as much as possible. Thomas (2004) also indicated that crews are faced with a variety of external threats and commit a range of errors that have the potential to impact negatively on safety in normal flight operations. The effective management of these threats and errors therefore forms an essential element of minimizing risks.

The situations in which pilots are required to make a decision are often complex. A number of factors may influence pilots' decision making, such as phase of flight, aircraft type, problem type, available time and the risks involved (Fischer, Orasanu, & Wich, 1995). Orasanu (1995) presented a model of aviation decision making that emphasized the role of situation assessment. Deciding on a course of action is contingent upon an adequate understanding of the nature of the problem and of the response options afforded by the problem situation. Risk and time pressure are situational variables that further constrain the decision process. Factors that influence the degree of risk and time pressure may call on the pilot to make an immediate response whether or not the problem is fully understood. Minimal risk levels and time constraints, in contrast, permit additional diagnostic actions or the deliberation of options.

O'Hare (1992) proposed that a good decision-making process is one in which the decision maker successfully accomplishes a series of tasks involving the collection of information about a wide range of alternatives, the careful assessment of the risks and benefits of each course of action, and results in the preparation of contingency plans for dealing with the known risks. When a significant threat to the likelihood of achieving a goal is perceived and no immediately applicable procedures exist, then a more deliberative mode of activity is required. The planning and situation awareness functions are linked by a risk assessment process that monitors the potential risks of the proposed plans. In the context of military aviation, this is already a risky environment but pilots play the role of risk takers whose primary mission is to be accomplished while still minimizing the risk through their skill and decision-making (Jensen, Guilke, & Tigner, 1997).

3.1.6 Time pressure and Decision-making

Time pressure has several obvious but important implications for decision-making. Firstly, decision makers will often experience high levels of stress, with the potential for exhaustion and loss of vigilance; secondly, their thinking will shift, characteristically in the direction of using less complicated reasoning strategies (Payne, Bettman, & Johnson, 1988). Stiensmeier-Pelster & Schurmann (1993) indicated that time stress may affect the process of decision making in a variety of ways depending on the type of decision. It may lead to reallocation of cognitive resources from the decision process to the stress coping process. Time stress may also change the goals of the decision-making process. Under time stress, cognitive resources may be allocated from the decision-making process to monitoring of the flow of time as part of a coping strategy (Zakay, 1993). Klein & Thordsen (1991) observed that decision makers in difficult situations and under time stress did not appear to use the classical approach to make decisions, even when they were trained in that approach. Much of the research on qualitative changes in cognitive performance, when stressors such as time pressure are present, is broadly consistent with the conflict theory of decision making proposed by Janis and Mann (1977).

Benson and Beach (1996) found that time pressure made the screening phase of problem identification less systematic. Unsystematic identification and screening processes can also occur in decisions concerned with ill-defined problems. The quality of decision-making may suffer even more from time stress in this case. Keinan (1987) found that under stress the range of alternatives and dimensions that are considered during a decision-making process is significantly restricted, compared with normal conditions. In brief, the effects of time stress on decision making are: (1) a reduction in information search and processing; (2) increased importance of negative information; (3) defensive reactions increase, such as neglect or denial of important information; (4) bolstering of the chosen alternative occurs; (5) forgetting important data happens; (6) poor judgments and evaluation are more likely; (7) there is a tendency to use a strategy of information filtration. Information that is perceived as being the most important is processed firstly, and then processing is continued until time is up.

Edland & Svenson (1993) found that under time pressure the following changes were observed in the decision-making processes: (1) an increased selectivity of input of information; (2) attributes perceived to be more important were given more weight under time pressure than in situations with no time pressure; (3) the accuracy of human judgment decreases; (4) the use of non-compensatory decision rules becomes more frequent than compensatory rules requiring value tradeoffs; (5) there is a decrease in the ability to find alternative problem-solving strategies; (6) motivation is attenuated.

Kaempf & Orasanu (1997) suggested that under conditions of time pressure, decision makers need help to determine what is occurring in the environment around them. Therefore, decision aids and training should provide decision makers with the tools and skills necessary to accurately and quickly make situation assessments. Payne, Bettman, and Johnson (1988) found that, under time pressure, a number of heuristic choice strategies are more useful than attempts to apply a truncated normative model. Subjects adapt their decision-making strategies in reasonable ways when placed under time constraints. Under time pressure, the likelihood of making serious errors increases. Decision makers tend to ignore relevant information, make risky decisions and perform with less skill (Foushee, 1984; Keinan, 1987). An implication of the fact that many decisions must be made under stress is that training should include extensive practice to learn key behaviours (Driskell & Salas, 1991). However, Zakay & Wooler (1984) found that practice without time pressure did not enhance decision-making under time constraints. This suggests that, if decision-making is likely to be required under time pressure or other stressful conditions, practice should include task performance under those conditions.

3.1.7 Experience and Decision-making

In most aviation situations, a pilot's ability to process information is facilitated by inter-correlation among cues. Expert pilots exploit this inter-correlation in their cue search and may perceive sets of correlated cues as a single perceptual chunk (Mosier, Skitka, Heers, & Burdick, 1998). They frequently use feature matching and pattern matching as diagnostic strategies. Pilots know and look for patterns or combinations of cues that are most relevant for diagnosing particular situations and they are able to incorporate contextual information to formulate a workable action plan based on their assessment of these cues (Kaempf & Klein, 1994). Kaempf & Orasanu (1997) illustrated that experienced aviators employ checklists and procedures differently compared to less experienced aviators. Those with less experience often relied only on checklists. However, experienced aviators considered a broader range of cues and learn when these cues are relevant. This enables them to employ checklists and procedures as guidelines rather than as absolute prescriptions of courses of action.

Camerer & Johnson (1997) found that experts are successful at generating hypotheses and inducing complex decision rules. Cohen, Freemen & Thompson (1997) suggested that the Recognition/Metacognition (R/M) decision making model explains how experienced decision makers are able to exploit their experience in a domain and at the same time handle uncertainty and novelty. The decision maker usually acts immediately unless the risk of delay is acceptable, the cost of an error is high, or the situation is unfamiliar. The inexperienced decision maker, however, often does not carefully assess how much time they have before they must commit themselves. More experienced decision makers buy more time for making a decision by considering the particulars of the situation.

The Recognition-Primed Decision (RPD) Model suggested that if there is enough time the decision maker will evaluate the dominant response option by imagining it, conducting a mental simulation to see if it will work. If it works, it will be implemented. If the solution runs into problems, it will be modified. If it can't be fixed, then it will be rejected, and another likely option will be considered. If there is not adequate time, the decision maker will implement the course of action that experience suggests as the most likely to be successful (Klein, 1993b). The degree of expertise a given pilot brings to the flight deck has a direct impact on the decision-making process. Domain experts organize information differently than novices, i.e., in 'chunks' rather than as individual items (Chase & Simon, 1973). They also may use different strategies for solving problems and making decisions, especially when under time constraints. Under time pressure, experts can make critical decisions by an intuitive, recognition process where a novice would need to use more analytic strategies (Klein, 1993a).

3.1.8 Aeronautical Decision-making Training Mnemonics

O'Hare (2003) described a number of acronyms/mnemonics to guide and structure decision-making. The aim of these techniques is to form a systematic approach to decision-making that should be less affected by human biases and should also reduce the cognitive workload for pilots. There is an increased need for military pilots to be trained specifically in making decisions in different tactical environments to improve aviation safety. Aviation psychologists studying aeronautical decision-making have suggested that ADM can be improved with training (Endsley, 1997; Jensen, 1997; Jensen & Hunter, 2002; Klein, 1997; Prince & Salas, 1993). Buch and Diehl (1984) found that judgment training produced significantly better decisions among civil aviation pilots. Connolly, Blackwell & Lester (1989) advised that pilot's decision-making skills could be significantly improved by the use of judgment training materials coupled with simulator practice. However, Orasanu (1993) has pointed out that there was no evidence to support the development of *generic* training techniques to improve all-purpose decision making skills, as there were different component skills involved in making the different basic types of decisions. The six basic types of decision are:

(1) Go/no go decisions: since these decisions usually must be made under severe time pressure and involve considerable risk, the amount of thinking should be minimal. Training design should focus on developing perceptual patterns in memory that constitute the conditions for an action. They should be trained under realistic time pressure and should include cases that have additional contingencies that require more complex risk assessment.

(2) Recognition-primed decisions: as with go/no go decisions, pilots must be trained to recognize situational patterns that serve as input to condition-action rules. But in a recognition-primed decision scenario, pilots must also learn the response side of the rule and its link to the condition.

(3) Response selection decisions: when a single option must be selected from a set, pilots must recognize multiple options and evaluate them in terms of how well they satisfy the goals and meet constraints. Often they must consider trade-offs among competing goals which are satisfied by different options.

(4) Resource management decisions: the relative priorities of various tasks, especially critical ones, must be part of the basic knowledge of all crewmembers. Skills that enter into this type of decision include estimation of the time required to complete various tasks, knowledge of interdependencies among tasks, and scheduling strategies.

(5) Non-diagnostic procedural decisions: This is the least clearly defined type of decision. It involves a cue pattern that falls into a category with no prescribed response. The nature of the problem is unclear. Many different types of ambiguous cues may signal dangerous conditions. Training for these cases would involve mainly situation assessment and risk assessment. Cues that signal possible emergencies need to be distinguished from those that are troublesome but not severe enough to precipitate an emergency landing.

(6) Creative problem-solving: these tasks are the most complex, because they involve both diagnosis to determine the nature of the situation and response generation. Once the nature of the problem has been determined, it may be found that there are no recommendations in the manuals. Pilots must determine what their goals are, develop a plan and candidate strategies, and evaluate these strategies and planned actions based on projections of outcomes (Orasanu, 1993).

Orasanu also suggested that decision-making ranged from simple to complex and their demands varied from little cognitive work to considerable mental effort. However, no guidance was provided for identifying the best training intervention for improving pilots' in-flight decision-making in different tactical environments. There is a need to investigate different types of decision-making training for improving the overall quality of pilots' decision-making.

3.1.8.1 SHOR Mnemonic

The SHOR mnemonic (Wohl, 1981) consists of four steps: Stimuli (data); Hypotheses (perception alternatives); Options (response alternatives); and Response (action). It was originally developed for use by U.S. Air Force tactical command and control, where decisions were required under high pressure and severe time constraints. The increasing information load in tactical aviation required an appropriate and effective decision aid for helping military pilots to make timely in-flight decisions (Figure 3.7).

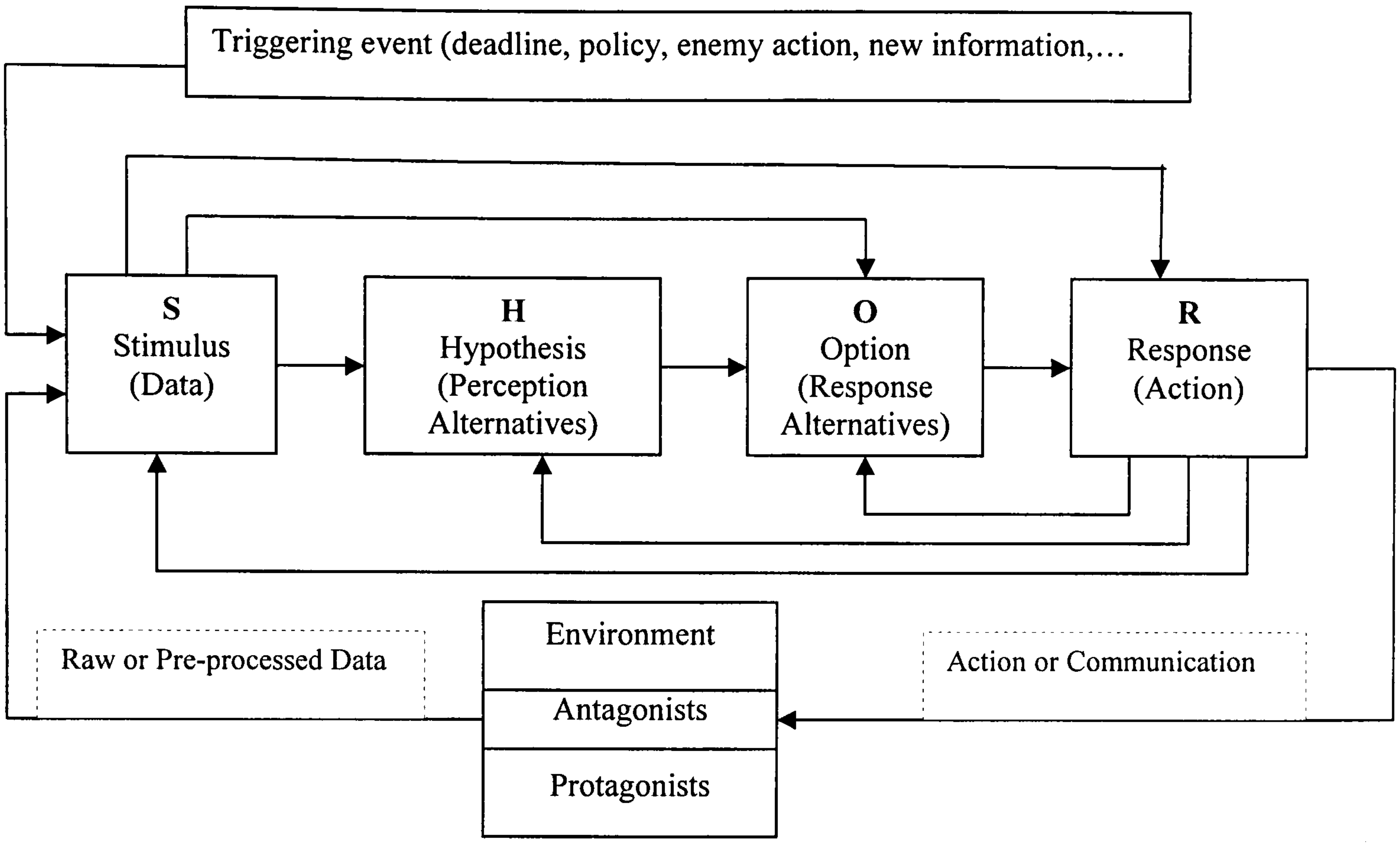


Figure 3.7 Dynamics of tactical decision process – the SHOR model

(From *Force Management Decision Requirements for Air Force Tactical Command and Control*, by Wohl, 1981)

The SHOR mnemonic is basically an extension of the stimulus- response (S-R) paradigm of classical behaviourist psychology extended to provide explicitly for the requirement to deal with two realms of uncertainty in the decision-making process: (1) information input uncertainty, which creates the need for hypothesis generation and evaluation; and (2) consequence-of-action uncertainty, which creates the need for option generation and evaluation.

3.1.8.2 PASS Mnemonic

PASS was originally developed by a civil airline (Delta) to train pilots as part of a CRM training program. Airline pilots are often required to make fast and safe decisions in a limited time period, usually in an information rich environment. PASS provides a heuristic approach to help pilots make in-flight decisions (Maher, 1989). The PASS mnemonic is based on Janis & Mann's decision-making model (1977). PASS consists of four steps: Problem identification (define/redefine problems); Acquire information (seek more information); Survey strategy (survey/resurvey strategies); Select strategy (Maher, 1989). After the selection of a solution strategy, if the problem is not solved, then the pilot should re-enter the problem solving loop (Figure 3.8).

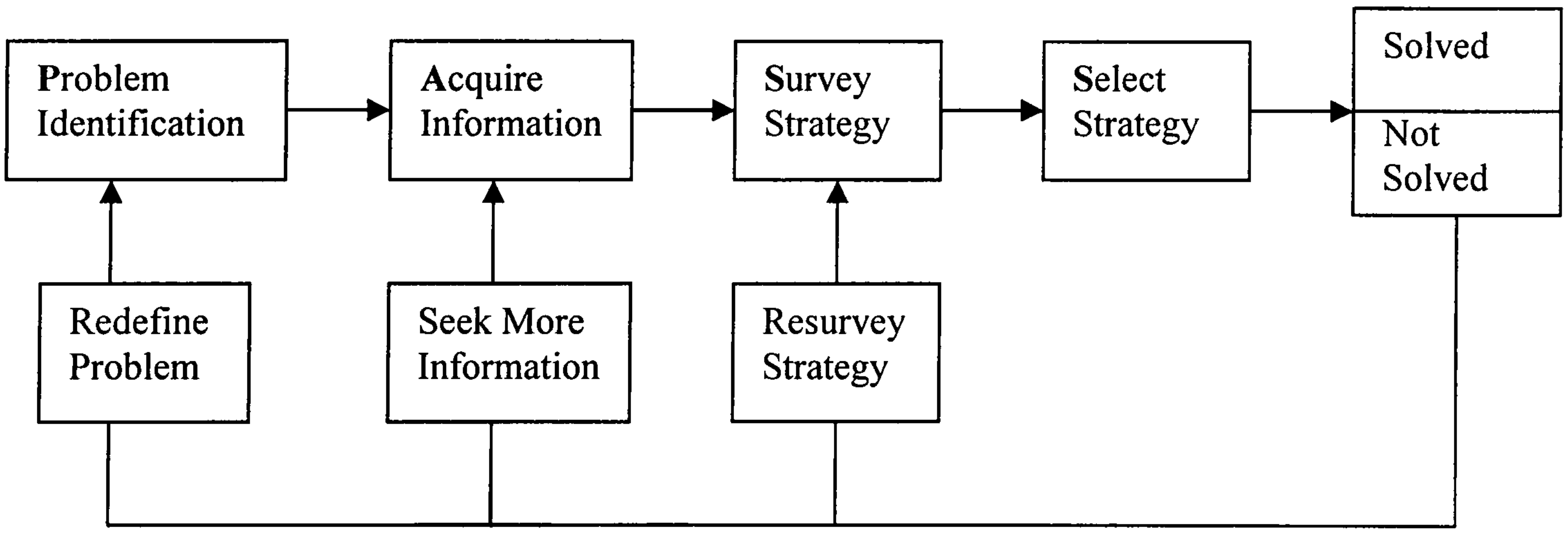


Figure 3.8 Decision heuristics – the PASS model

(From *Beyond CRM to Decisional Heuristics: An Airline Generated Model to Examine Accidents and Incidents Caused by Crew Errors in Deciding*, by Maher, 1989)

3.1.8.3 SOAR Mnemonic

The SOAR mnemonic decision making method (Oldaker, 1996) comprises of four steps, Situation, Options, Act, Repeat. It has the strength of repeating the evaluation of a changing situation after the initial actions have been made. In aviation, a decision is often merely the pre-cursor to another decision or series of complex decisions to achieve mission success. The mnemonic was originally developed for glider pilots and applied to gliding.

The first step in SOAR is 'situation'. This is the important part of seeing the situation from the perspective of where and what the aircraft is doing. There are three factors, pilot, environment and aircraft, all of which must be considered. The second step is 'options'. Pilots use their experience to predict what will happen for the option they might choose. Each prediction must include an estimate of the benefit of choosing that option. The third step is 'acting'. After pilots have chosen the option that provides the greatest benefit, it is important to act appropriately. This immediately leads to a new situation, and so the fourth step is 'repeating the process'. The pilot needs to compare the results of his decision to his predictions for the chosen option. This builds up his experience to make more accurate future predictions (Oldaker, 1996). An example of applying SOAR mnemonic in a broken tow-rope emergency in a glider is shown in Figure 3.9.

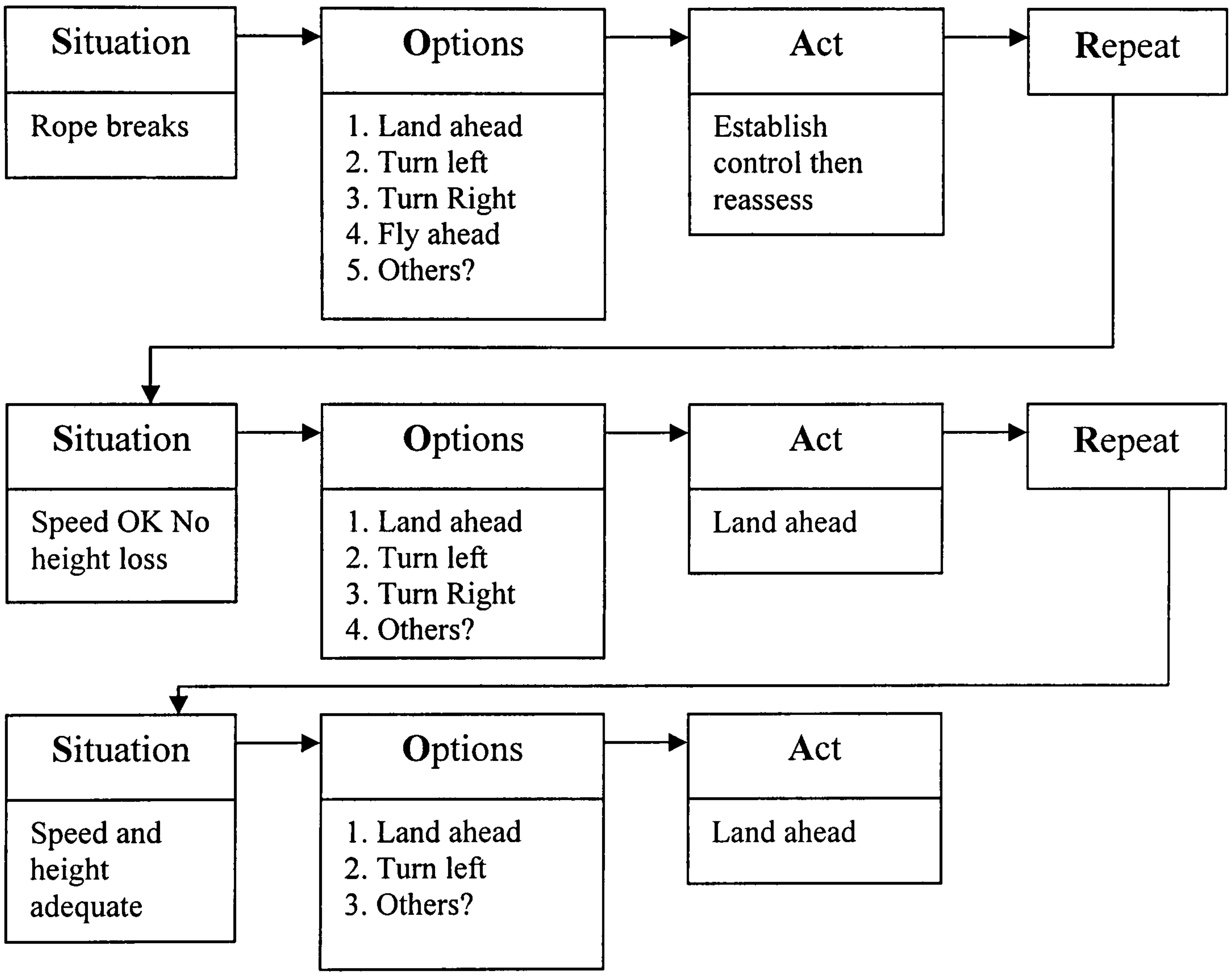


Figure 3.9 Decision-making training for glider pilots – the SOAR model

(From *Pilot Decision-making – An Alternative to Judgement Training*, by Oldaker, 1996)

3.1.8.4 FOR-DEC Mnemonic

Prescriptive models for ADM are defined as 'quick and easy' heuristic methods to structure the process of decision-making (O'Hare, 1992). There are a series of steps which must be followed to improve the quality of pilots' decision-making. The FOR-DEC mnemonic is a prescriptive model to aid decision-making developed from the contents of a Lufthansa CRM-course. It comprises of six steps: Facts, Options, Risks & Benefits, Decision, Execution, Check (Hormann, 1995). It incorporates an analysis of risk and benefits to handle situations, including the effects of time pressure, continually changing conditions, distraction, and having incomplete information. The advantage of such a simple prescriptive model is that it can easily be remembered to help pilots to structure the decision-making processes in the cockpit. FOR-DEC covers primarily three broad subjects: communication, teamwork and decision-making. It is designed to counteract certain cognitive mechanisms that can adversely affect the quality of pilots' in-flight decision-making.

Each step of the FOR-DEC process is connected to a guiding question which should help to focus the pilot's attention on a sequence of essential steps for effective decision-making. The phases of the FOR-DEC model, as shown in figure 3.10, are: (1) Facts: What is actually going on here? (2) Options: What are the choices we've got? (3) Risk & Benefits: What is there to be said for and against the application of the different options? (4) Decision: So, what shall we do after all? (5) Execution: Who shall do what, when, and how? (6) Check: Is everything still all-right? (Hormann, 1995).

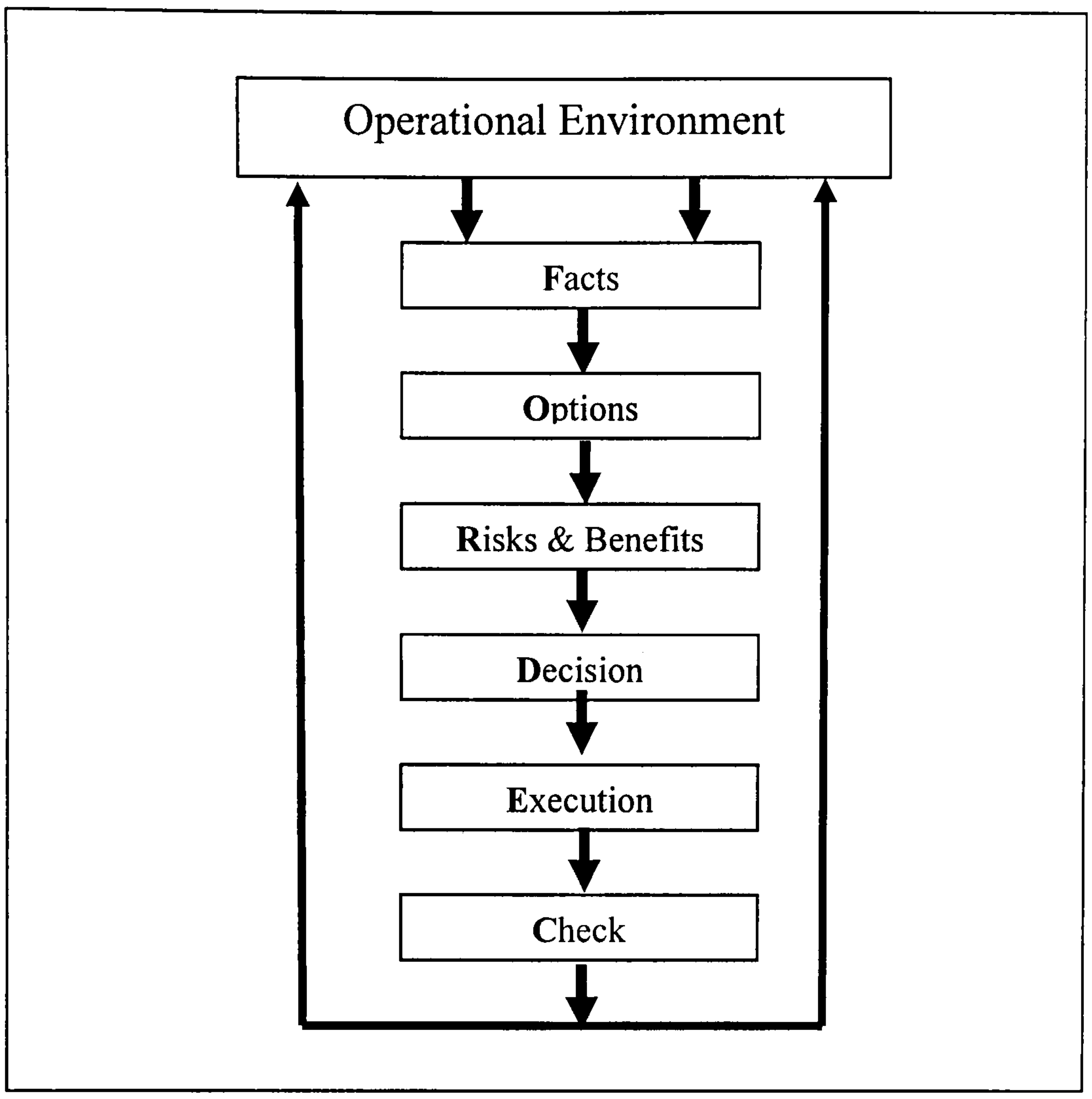
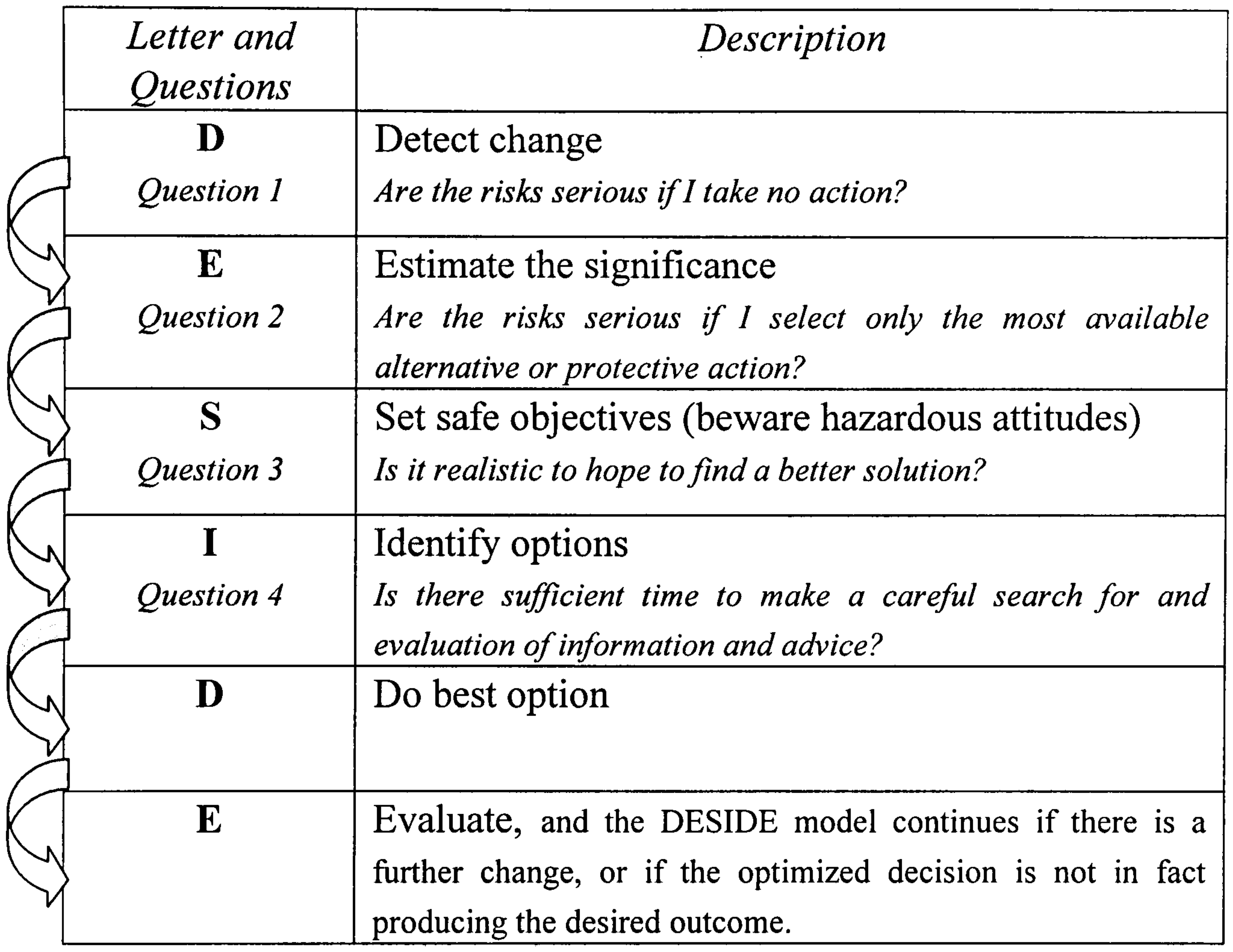


Figure 3.10 FOR-DEC model of aeronautical decision-making

(From *FOR-DEC: A Prescriptive Model for Aeronautical Decision-making,* by Hormann, 1995)

3.1.8.5 DESIDE Mnemonic

The DESIDE mnemonic method (Murray, 1997) was developed on a sample of South African pilots. It comprises of six steps, Detect, Estimate, Set safety objectives, Identify, Do, Evaluate (figure 3.11). The DESIDE method is a practical application adapted from conflict-theory model of Janis and Mann (1977). The reasons for modifying DECIDE to DESIDE (an incorrect spelling of the word '*decide*') was to make the mnemonic somewhat more memorable, and 'S', 'set safe objectives', is a clear reminder to pilots that objectives need to be carefully considered, not only in terms of the originally desired outcomes, but also by taking into account the newly changed, unanticipated circumstances (Murray, 1997).



Letter and Questions	*Description*
D *Question 1*	Detect change *Are the risks serious if I take no action?*
E *Question 2*	Estimate the significance *Are the risks serious if I select only the most available alternative or protective action?*
S *Question 3*	Set safe objectives (beware hazardous attitudes) *Is it realistic to hope to find a better solution?*
I *Question 4*	Identify options *Is there sufficient time to make a careful search for and evaluation of information and advice?*
D	Do best option
E	Evaluate, and the DESIDE model continues if there is a further change, or if the optimized decision is not in fact producing the desired outcome.

Figure 3.11 An integration of the adapted conflict theory and the DESIDE model (From *Deliberate Decision-making by Aircraft Pilots: A Simple Reminder to Avoid Decision-making Under Panic*, by Murray, 1997)

3.1.9 Similarities and Differences between the ADM Mnemonics

There are a number of strategies embodied in the mnemonics describing the processes and procedures concerned with ADM. The five ADM mnemonic-based methods that could potentially improve pilots' in-flight decision-making that were selected as followings (Li & Harris, 2005):

- SHOR: Stimuli, Hypotheses, Options, Response (Wohl, 1981).
- PASS: Problem identification, Acquire information, Survey strategy, Select strategy (Maher, 1989).
- SOAR: Situation, Options, Act, Repeat (Oldaker, 1996).
- FOR-DEC: Facts, Options, Risks & Benefits, Decision, Execution, Check (Hormann, 1995).
- DESIDE: Detect, Estimate, Set safety objectives, Identify, Do, Evaluate (Murray, 1997).

A similarity of these five mnemonic-based methods is that they all start from situation assessment for gaining situation awareness, including fast changing abnormal situations in a dynamic environment. All of these five ADM mnemonic-based methods follow a logical structure to form the safest strategy. These mnemonics have been developed in recent years by researchers and used by pilots to support ADM 'best practice'. They share some common characteristics but have certain differences. For example, (1) SHOR and PASS are focused on making quick actions (such as Response in SHOR and Select Strategies in PASS). The other three mnemonics are more comprehensive for considering a changing situation resulting from the pilots original actions (such as Repeat in SOAR; Check in FOR-DEC; and Evaluate in DESIDE). (2) SHOR, PASS and SOAR have only four steps for decision-making, however, FOR-DEC and DESIDE have six steps. (3) SHOR was originally developed for use in the Air Force Tactical Command and Control situations; SOAR had been used for training glider pilots; PASS, FOR-DEC and DESIDE been developed for using in Civil Airlines, as parts of CRM training. (4) SHOR was an extension of the stimulus-response (S-R) paradigm of classical behaviourist psychology (Wohl, 1981); PASS is a description of reality and simplified for classroom use based on

Janis and Mann's model (1977); SOAR was derived from adaptive management techniques which was used in making business decisions; FOR-DEC promoted teamwork and communication between crew members for tasks that can be shared by crew members; the DESIDE model is also based on conflict-theory model (Janis & Mann, 1977).

3.1.10 Research Purposes

There was actually no evidence to support these ADM mnemonics had improved the quality of pilots' decision-making, although these mnemonic methods have been developed for many years. The purposes of the second study are to evaluate the best ADM training mnemonics in six different decision-making situations, and to elicit any differences between experienced and inexperienced pilots with regard to their judgments about the suitability of the five various ADM mnemonics for use in the six different decision-making scenarios, as described by Orasanu (1993). The ADM mnemonics selected from this research will be utilised to form the basis of a short decision-making training course.

3.2 Method

3.2.1 ADM Training Mnemonics

Five ADM mnemonic methods that could potentially form the basis of the ADM training program were selected from a review of the literature by a research team comprising of three instructor pilots and one aviation psychologist. These were SHOR (Wohl, 1981); PASS (Maher, 1989); SOAR (Oldaker, 1996); FOR-DEC (Hormann, 1995); and DESIDE (Murray, 1997). These mnemonics were described briefly in the previous section.

3.2.2 Participants

There were 107 participants, including 60 instructor pilots and 47 cadet pilots. Instructor pilots had between 1,175 and 10,000 hours flying experience, the average being 3,788 hours in the R.O.C. Air Force Academy. Cadet pilots had between 204 and 800 hours flying experience, with an average of 281 hours. None of the participants had any previous experience in employing these five structured decision-making training mnemonics.

3.2.3 Selection of Scenarios and Development of Rating Materials

Six scenarios taken from the R.O.C. Air Force accidents and incidents database corresponding to the six types of decisions proposed by Orasanu (1993) were used as stimulus material in the evaluation of the suitability of the ADM mnemonic methods for forming the basis of training.

To develop a rating instrument for the subsequent evaluation of the suitability of the ADM mnemonic-based methods, six focus groups were formed, one for each scenario. Each comprised one human factors specialist and three senior instructor pilots. The purpose of these groups was to verify that the scenario selected from the database of R.O.C. air force accidents and incidents corresponded to the appropriate type of decision making scenario (see Orasanu, 1993). These focus groups also ensured enough detail was available in the scenario description to enable a thorough evaluation of the suitability of the mnemonic methods. The six selected scenarios were analyzed by the focus group members using all five mnemonic methods. This process provided the material for the construction of a rating form to evaluate the suitability of the ADM mnemonics for decision-making training.

The rating form (see Appendix 8.1) developed required participants to evaluate each mnemonic on four dimensions, each using a nine-point Likert-type scale (with a high score of 9 and a low score of 1), in terms of its suitability for situation assessment (Endsley, 1995 & 1997; Kaempf & Orasanu, 1997; Sarter Woods, 1991); risk management (Jensen, Guilke & Tigner, 1997; Orasanu, Davison & Fischer, 2001; Slovic, 1987; Thomas, 2003 & 2004); response time (Benson &Beach, 1996; Klein & Thordsen, 1991;Payne, Bettman, & Johnson, 1988; Stiensmeier-Pelster & Schurmann, 1993; Zakay, 1993); and applicability (Kaempf & Klein, 1994; Kaempf & Orasanu, 1997; Klein, 1993; Mosier, Skitka, Heers & Burdick, 1998). Further space was allowed for respondents to add qualitative comments justifying their reasons for the ratings awarded.

It was decided to use rating scales rather than a ranking procdure for several reasons. Likert-scale type data, similar to the data obtained from the rating scales used, are best described as 'scalar' data, a higher order of data than ordinal (ranking) data but not as high as interval. All statistical procedures based upon the General Linear Model are extremely robust from even quite major deviations from normality in either the dependent or independent variable. The application of order methods is now often not recommended in circumstances such as those encountered in this research. When applying order methods with a moderately large sample size (in excess of 20-30) in a study using Likert-scale data, there can be a great many instances of tied ranks within the data set which effectively eliminates these data from the analysis leaving the final result dependent upon very few observations in the overall sample, hence the relatively poor statistical power of non-parametric order-based methods (Hays, 1981). It can easily be demonstrated that once a sample size exceeds about 30, all non-parametric statistical distributions tend toward normality. Thus, there is little merit in applying non-parametric techniques with a sample size of 41. Furthermore, collection of higher-ordr raing-type data allows subsequent reduction of data to rank data, but not vice versa. As a result, it was thought that the collection of data using rating scales allowed greater flexibility in analysis and also more ppowerful analytical techniques to be applied.

3.2.3.1 Go/no go Decision Scenario

Scenario 1: F-5E No. 2 wingman has to make a decision as the No. 1 (Leader) abandons a tactical formation take-off at 145 knots.

3.2.3.2 Recognition-primed Decision Scenario

Scenario 2: F-5E right engine fails as a result of Foreign Object Damage (FOD) just as the nose gear leaves the ground at a speed 165 knots.

3.2.3.3 Response Selection Decision Scenario

*Scenario 3: No. 4 in a tactical formation of F-*5Es *is required to make a decision when No. 1 (Leader) becomes lost in cloud during formation flight (3 feet distance between wing tips of the four fighters).*

3.2.3.4 Resource Management Decision Scenario

Scenario 4: F-5E leader (No. 1) of 4 aircraft needs to make a decision for the No.3 and No. 4 aircraft when a 'no joy' call (no visual contact with No. 1 and No. 2) is made and No. 2 calls 'one opposing target approaching on 12:30 o'clock with same altitude'. This occurs during practice of a 2 versus 2 engagement (Air Combat Manoeuvre).

3.2.3.5 Non-diagnostic Procedural Decision Scenario

Scenario 5: Both the leader and wingman in a formation of F-5Es are unable to land at home-base in a 'bingo' (low fuel) situation during instrument flight in bad weather.

3.2.3.6 Creative Problem-solving Scenario

Scenario 6: When flying an F-5F both left and right generators fail at the same time during a tactical manoeuvre.

3.2.4 Administration of Rating Forms

As a result of the length of the scenarios and the number of ratings required each participant only evaluated the ADM decision techniques in three scenarios selected randomly from a total of six. To eliminate order effects, the five ADM mnemonic-based methods were presented in a randomized order within each scenario. The ADM rating forms were distributed to Cadet Pilots and Instructors in the Training Division, R.O.C. Air Force Academy. Completed instruments were returned to the researcher the following day. For each participant an overall score for each mnemonic method in each scenario was created by summing the scores across situation assessment; risk management; response time; and applicability giving a potential range of scales between 4 (low suitability) to 36 (high suitability).

3.2.5 Ethics

This research program was approved by the Ethics committee of Cranfield University. This committee operates to the principles prescribed by the British Psychological Society (the UK professional body for psychologists). Participants were informed of the purpose of the study prior to participating. The data were collected anonymously.

3.3 Results

3.3.1 Sample Characteristics

In total, data were collected from 319 scenarios. There were 51 (29 Instructors, 22 Cadets) completed rating forms for the go/no go decisions scenario; 57 (35 Instructors, 22 Cadets) for the recognition-primed decision-making scenario; 58 (32 Instructors, 26 Cadets) for the response selection decision-making scenario; 44 (22 Instructors, 22 Cadets) for the resource management scenario; 57 (32 Instructors, 25 Cadets) for the non-diagnostic procedural decisions-making scenario, and 52 (30 Instructors, 22 Cadets) completed rating forms for the creative problem-solving scenario.

3.3.2 Go/no go Decisions

The highest overall rating of suitability for the ADM mnemonics in the go/no go decision-making scenario by instructors was received by PASS followed by SHOR, DESIDE, FOR-DEC, and SOAR; the highest overall rating by cadets, in order, was SHOR, SOAR, FOR-DEC, PASS, and DESIDE (see Table 3.1). There was no significant difference in the summated suitability scores between Instructors and Cadet Pilots when assessing the decision making mnemonics in the go/no go decision-making scenario, F (1, 49)=1.176; p=0.283. There were also no significant differences in the ratings of suitability among the five ADM mnemonics, F (4, 196) =0.735; p=0.569. However, the qualitative data suggest that PASS was regarded by the instructors as providing a method for a quick decision-making response in urgent situations with a logical order for promoting safety. PASS also matched the instructors' own training guidelines for this scenario as it had clear and specific procedures to follow. FOR-DEC and DESIDE were regarded as being comprehensive but did not fit this scenario as time was very limited. SHOR enabled a quick response to be made in urgent situations and was simple to practice. SOAR was regarded as being easy to understand, however, it was also thought to need frequent practice on the ground to be familiar with the process.

Table 3.1 Individual scale means (situation assessment; risk management; response time; and applicability) and overall mean for Instructor and Cadet ratings for the suitability of each ADM mnemonic method for scenario 1: Go/no go decisions

ADM mnemonic method		N	Situation assessment	Risk management	Response time	Applicability	Overall Mean	Std. Deviation
SHOR	Instructors	29	6.62	6.31	6.07	6.21	25.21	5.70
	Cadets	22	6.55	6.50	7.00	6.82	26.86	5.78
PASS	Instructors	29	6.55	6.38	5.97	6.38	25.28	5.84
	Cadets	22	6.32	6.55	6.27	6.68	25.82	4.61
FOR-DEC	Instructors	29	6.24	6.24	6.10	5.90	24.48	4.56
	Cadets	22	6.73	6.36	6.36	6.41	25.86	5.06
SOAR	Instructors	29	5.97	6.00	5.76	5.83	23.56	6.60
	Cadets	22	6.36	6.45	6.55	6.59	25.95	3.86
DESIDE	Instructors	29	6.48	6.52	5.90	6.21	25.11	5.44
	Cadets	22	6.55	6.50	5.68	6.23	24.95	4.10

3.3.3 Recognition-primed Decisions

The highest overall rating of suitability for the ADM mnemonics by instructors was received by SHOR followed by SOAR, PASS, DESIDE, and FOR-DEC. The highest overall rating by cadets, in order, was SOAR, PASS, SHOR, FOR-DEC, and DESIDE (see Table 3.2). There was no significant difference in the summated suitability scores between Instructor and Cadet Pilots when assessing the decision making mnemonics in the recognition-primed decision-making scenario, F (1, 55)=0.585; p=0.448. However, there were significant differences among the rated overall suitability of the five ADM mnemonics in this scenario, F(4, 220)=3.188; p=0.014. Further comparisons using post-hoc t-tests showed significant differences between SHOR (mean=26.42) vs. FOR-DEC (mean=24.07); t=2.77, df=56, p=.007, and SHOR (mean=26.42) vs DESIDE (mean=24.14); t=2.83, df=56, p=.006. Table 3.3 contains the qualitative data with the opinions of both Instructor and Cadet Pilots about these ADM mnemonics within this scenario.

Table 3.2 Individual scale means (situation assessment; risk management; response time; and applicability) and overall mean for Instructor and Cadet ratings for the suitability of each ADM mnemonic method for Scenario 2: Recognition-primed decisions

ADM training acronyms		**N**	**Situation assessment**	**Risk management**	**Response time**	**Applicability**	**Overall Mean**	**Std. Deviation**
SHOR	**Instructors**	35	6.71	6.63	6.83	6.46	26.63	5.01
	Cadets	22	6.59	6.36	6.55	6.59	26.09	3.11
PASS	**Instructors**	35	6.23	6.37	6.26	6.23	25.09	5.69
	Cadets	22	6.32	6.32	6.95	6.82	26.41	4.93
FOR-DEC	**Instructors**	35	6.54	6.20	5.37	5.51	23.62	6.09
	Cadets	22	6.59	6.41	5.64	6.14	24.77	6.01
SOAR	**Instructors**	35	6.34	6.29	6.57	6.00	25.20	6.86
	Cadets	22	6.64	6.68	6.95	6.77	27.05	4.94
DESIDE	**Instructors**	35	6.31	6.46	5.46	5,71	23.94	6.63
	Cadets	22	6.32	6.09	5.77	6.27	24.45	4.81

Table 3.3 Opinions of Instructor and Cadet pilots with regard to the suitability of the five ADM mnemonic-based methods in the Recognition-primed decision scenario

Recognition-primed decisions		
	Instructor pilots	**Cadet pilots**
SHOR	1. Simple and thorough to help reach a quick decision 2. Effective with specific actions specified for completion in a very short time 3. SHOR has logical responses matches the flight simulator training scenario with which, cadets are familiar and practice several times 4. Assesses the situation precisely and has encourages safe actions 5. Quickly analyzes the problem and evaluates the options for safe actions	1. Encourages thinking about the effect of the hypotheses for a follow-up action 2. You need to respond quickly when evaluating options during take-off, abort take-off, or parachuting, SHOR fits these requirements 3. Provides a quick resolution 4. Makes you aware of the current position and helps choose the best option for action 5. Evaluate the situation by stimuli and hypotheses is good for reducing risk
PASS	1. Matches the principles of military aviation 2. Fits with the time limited situations for immediate action 3. Provides easy guidance for judging and executing procedures in emergent situations 4. Identifies problems and helps select the best options quickly	1. The simplest strategy to eliminate risk 2. Quick and with specific decision points for urgent situations 3. Helps reach the appropriate decision quickly 4. Low altitude and low airspeed needs a quick response
FOR-DEC	1. Considers the risks and benefits for making decisions but does not fit this emergent situation, it need be done by automatic response and quickly 2. Considers the details when checking items for safety, however, time is limited 3. Good for situation assessment and risk management, but you need to have time to do so	1. Has a loop from options to check and to risks and benefits, however, it takes time 2. Is able to consider the whole situation before making decisions, but an engine failure is a time-limited situation, so needs quick action
SOAR	1. Efficient and safe 2. Catches the highest priority action for safety and is able to respond to urgent situation 3. Easy to apply and to reach a safe decision quickly	1. Provides quick analysis of the problems for effective action, then repeats the evaluation process for follow-up 2. Highly applicable
DESIDE	1. Too many steps, requires more consideration, more time consuming and more dangerous 2. Logic is comprehensive but it does take much time 3. The analysis is specific and reasonable, however there is no available time in emergent situations	1. Good for risk management, but the detail in the acronym is a bit complicated 2. Response to risk is effective but does not fit critical time-limited situations 3. FOR-DEC and DESIDE do not fit urgent situations but both are good for training scenarios with more time to practice

The comments in table 3.3 suggest that the reasons for the superior ratings received by SHOR, PASS and SOAR in this situation were because these mnemonic-based decision making methods were fastest to undertake. FOR-DEC and DESIDE were regarded as comprehensive but too slow to apply in a time-limited emergency situation. Instructors' comments showed that SHOR was thought to be simple and thorough but comprehensive enough to reach a safe decision in a short time. It was also in accordance with the principles taught during flight simulator training. SHOR was regarded as being able to help the precise assessment of a situation and it contained a logical order for dealing with an emergent situations. Cadets' opinions suggested that SOAR and PASS also fitted the requirements of an emergent and time limited situation but needed more practice on the simulator. Making urgent, time-pressured decisions in the air benefits from practicing decision-making on the ground, as normally decisions need to be made in one or two seconds. FOR-DEC had a good logical order of operations however it required too much time to assess the situation. DESIDE was rated as being good for risk management but was also thought to take too much time to analyze the situations.

3.3.4 Response Selection Decisions

In this scenario, the highest overall rating of suitability for the ADM mnemonics by instructors was received by DESIDE followed by PASS, SOAR, SHOR, and FOR-DEC. The highest overall rating by cadets in order was DESIDE, FOR-DEC, SOAR, and SHOR (see Table 3.4). There were no significant differences in the summated suitability scores between Instructors and Cadet Pilots when assessing the mnemonics in the response selection decision-making scenario, F (1, 56)=1.410; p=0.240. There were also no significant differences in the ratings of suitability among the five ADM mnemonics, F(4, 224)=1.279; p=0.279. The qualitative comments showed that DESIDE was thought to contain appropriate considerations for safe actions, quick responses, was easy to practice and promoted situation awareness. SOAR, PASS and SHOR were regarded as promoting quick responses, however there were no time pressures in this scenario. FOR-DEC was regarded as not fitting the requirements for making a quick response.

Table 3.4 Individual scale means (situation assessment; risk management; response time; and applicability) and overall mean for Instructor and Cadet ratings for the suitability of each ADM mnemonic method for Scenario 3: Response selection decisions

ADM training acronyms		N	Situation assessment	Risk management	Response time	Applicability	Overall Mean	Std. Deviation
SHOR	**Instructors**	32	6.00	5.97	6.06	5.94	23.97	6.43
	Cadets	26	5.96	6.12	6.00	6.04	24.12	4.09
PASS	**Instructors**	32	6.22	6.25	6.09	6.16	24.72	5.53
	Cadets	26	6.15	6.12	6.15	6.38	24.81	4.05
FOR-DEC	**Instructors**	32	6.22	6.16	5.59	5.94	23.91	7.58
	Cadets	26	6.77	6.69	6.31	6.65	26.42	5.01
SOAR	**Instructors**	32	6.09	6.13	6.06	6.03	24.31	6.09
	Cadets	26	6.38	6.42	6.35	6.58	25.73	4.81
DESIDE	**Instructors**	32	6.41	6.22	5.97	6.16	24.74	7.38
	Cadets	26	7.08	6.73	6.46	6.81	27.08	4.58

3.3.5 Resource Management Decisions

The highest overall rating of suitability for the ADM mnemonics by instructors was SHOR followed by DESIDE, FOR-DEC, SOAR, and PASS. The highest overall rating by cadets in order was FOR-DEC, SOAR, DESIDE, PASS, and SHOR (see Table 3.5).

There were no significant differences in the summated suitability scores between Instructors and Cadet Pilots when assessing the applicability of the decision-making mnemonic methods in the resource management decision-making scenario, F (1, 42)=1.291; p=0.262. There were also no significant differences in the ratings of suitability among the five ADM mnemonic methods themselves, F(4, 168)=0.465; p=0.761. The qualitative comments suggested that FOR-DEC was regarded as promoting a comprehensive consideration of the situations and it contained a logical order to deal with uncertain situations. DESIDE was regarded as promoting good situation assessment but was much too time consuming. SHOR and PASS were thought to be very easy to remember but did not match the requirements of this situation.

Table 3.5 Individual scale means (situation assessment; risk management; response time; and applicability) and overall mean for Instructor and Cadet ratings for the suitability of each ADM mnemonic method for Scenario 4: Resource management decisions

ADM training acronyms		N	Situation assessment	Risk management	Response time	Applicability	Overall Mean	Std. Deviation
SHOR	Instructors	22	6.59	6.32	6.41	6.23	25.55	6.02
	Cadets	22	6.77	6.32	6.36	6.00	25.45	4.82
PASS	Instructors	22	5.82	5.77	5.82	5.77	23.18	6.02
	Cadets	22	6.50	6.77	6.41	6.68	25.45	4.82
FOR-DEC	Instructors	22	6.50	6.36	6.00	6.36	25.22	6.09
	Cadets	22	7.00	7.32	6.64	6.86	27.82	4.56
SOAR	Instructors	22	6.32	6.14	6.27	5.73	24.46	6.08
	Cadets	22	6.82	6.86	7.00	6.55	27.23	4.74
DESIDE	Instructors	22	6.88	6.41	5.91	6.05	25.25	5.66
	Cadets	22	7.05	6.59	6.59	6.50	26.73	4.83

3.3.6 Non-diagnostic Procedural Decisions

The highest overall rating of suitability for the ADM mnemonics by instructors was received by SHOR followed by PASS, SOAR, FOR-DEC, and DESIDE; the highest overall rating by cadets in order was DESIDE, PASS, SOAR, FOR-DEC, and SHOR (see Table 3.6). There were no significant differences in the overall summated suitability scores between instructors and cadet pilots in the non-diagnostic procedural decision-making scenario, F (1, 55) =0.341; p=0.561.

Table 3.6 Individual scale means (situation assessment; risk management; response time; and applicability) and overall mean for Instructor and Cadet ratings for the suitability of each ADM mnemonic method for scenario 5: Non-diagnostic procedural decisions

ADM training acronyms		N	Situation assessment	Risk management	Response time	Applicability	Overall Mean	Std. Deviation
SHOR	**Instructors**	30	6.37	6.23	6.47	6.33	25.40	5.10
	Cadets	25	6.28	6.24	6.60	6.40	25.52	3.79
PASS	**Instructors**	30	6.30	6.30	6.43	6.27	25.30	5.42
	Cadets	25	6.52	6.64	6.88	6.92	26.96	4.73
FOR-DEC	**Instructors**	30	6.37	6.20	5.77	6.00	24.34	5.52
	Cadets	25	6.52	6.60	6.48	6.76	26.36	5.71
SOAR	**Instructors**	30	6.50	6.13	6.07	6.30	25.00	4.83
	Cadets	25	6.56	6.60	6.48	6.76	26.40	4.09
DESIDE	**Instructors**	30	6.33	5.97	5.77	5.97	24.04	6.06
	Cadets	25	6.76	6.88	6.64	6.92	27.20	4.31

Table 3.7 Opinions of instructors and cadet pilots with regard to the suitability of the five ADM mnemonic-based methods in the Non-diagnostic procedural decision-making scenario

Non-diagnostic procedural decisions		
	Instructor pilots	**Cadet pilots**
SHOR	1. SHOR is quicker 2. Low fuel is not an emergency situation and needs comprehensive considerations, SHOR is not the best strategy	1. There is a need to consider more risks and benefits for other alternative landing airfields, SHOR is not capable of analyzing a complex situation 2. SHOR is applicable and matches the critical situation 3. Simple
PASS	1. PASS fit for quick action, however, this is not an urgent situation 2. Too simplistic for the situation and lacks the ability to evaluate the risks and benefits for other alternative airfields	1. Decisions need to be made quickly before fuel becomes low 2. Weather and low fuel conditions need quick action 3. Helps make the right decision in a short time
FOR-DEC	1. Good situation assessment and risk management 2. FOR-DEC is the safest 3. Logically reasonable 4. Comprehensive analysis followed by execution 5. Comprehensive consideration of risks and benefits of alternative landing airfields	1. FOR-DEC has comprehensive considerations especially the C (check) for the effect of action is good for promoting safety 2. In this scenario there is time to consider the best strategy 3. It is important to check the situation after making an action, so FOR-DEC is good 4. This is not an urgent situation, FOR-DEC is able to consider the whole situation for the best action
SOAR	1. SOAR is the safest strategy for good situation assessment 2. Quick action	1. Re-formation for landing at another base is safer than remaining alone 2. Promotes quick action to avoid consuming fuel
DESIDE	1. DESIDE is good for situation assessment: as this scenario is not urgent, it is good to have time to think thoroughly 2. Good for risk management and highly applicable 3. Comprehensive consideration 4. Provides specific analysis and safe	1. Provides a more detailed analysis - more safety 2. Comprehensive consideration for set safety objectives 3. Minimizes potential risk to ensure the safety 4. Identifies the safe objectives for actions 5. Has a logical order - easy to remember

However, there were significant differences in the ratings of the suitability of the five ADM mnemonic-based methods, F(4, 220)=3.352; p=0.011. There were four significant post-hoc t-tests, SHOR (mean=25.00) vs PASS (mean=26.42); t=-2.53, df=56, p=.014; SHOR (mean=25.00) vs FOR-DEC (mean=26.56); t=-2.30, df=56, p=.025; SHOR (mean=25.00) vs DESIDE (mean=27.04); t=-3.49, df=56, p=.001; and SOAR (mean=25.53) vs DESIDE (mean=27.04); t=-2.39, df=56, p=.020.

The qualitative data containing the opinions of instructor pilots and cadet pilots with regard to the suitability of the five ADM mnemonic-based methods in the non-diagnostic procedural decision-making scenario are contained in table 3.7. It will be noted from the comments in table 3.7 that there are some qualitative differences between the comments elicited from instructor and cadet pilots. In general, there would seem to be more urgency perceived in this tactical situation by the Instructors than by the Cadet pilots. The qualitative comments from the Cadets indicated that DESIDE was regarded as promoting good situation assessment, risk management and was highly applicable as this was not an urgent situation. It was, however, necessary to think the situation through thoroughly. However, Instructors' opinions suggested there were many unexpected situations in the air and the main priority was to eliminate the risk and promote awareness of the changing situations hence quick responses were needed to implement a solution as soon as possible, as the fuel was limited.

3.3.7 Creative Problem-Solving

The highest overall rating of suitability for the ADM mnemonics by instructors was received by DESIDE followed by FOR-DEC, PASS, SOAR, and SHOR; the highest overall rating by cadets, in order, was FOR-DEC, DESIDE, SHOR, PASS, and SOAR (see Table 3.8). There were no significant differences in the overall suitability scores between instructors and cadet pilots in the creative problem-solving scenario, F (1, 50)=1.038; p=0.313. There were also no significant differences in the ratings of suitability among the five ADM mnemonic-based methods, F(4, 200)=0.292; p=0.883. The qualitative comments of Instructors revealed that DESIDE was regarded as promoting an effective response in a non-time-limited situation (the backup battery has about nine minutes power for both generators failures). It was also regarded as progressing in a logical order and was easy to remember. However, Cadets preferred FOR-DEC as it provide a more comprehensive consideration and analysis of potential risks and benefits.

Table 3.8 Individual scale means (situation assessment; risk management; response time; and applicability) and overall mean for Instructor and Cadet ratings for the suitability of each ADM mnemonic method for Scenario 6: Creative-problem solving

ADM training acronyms		N	Situation assessment	Risk management	Response time	Applicability	Overall Mean	Std. Deviation
SHOR	Instructors	32	6.28	6.06	6.16	6.09	24.59	6.51
	Cadets	22	6.23	6.41	6.55	6.77	25.95	4.13
PASS	Instructors	32	6.56	6.63	6.44	6.38	26.00	5.69
	Cadets	22	6.00	6.14	6.50	6.68	25.32	4.86
FOR-DEC	Instructors	32	6.84	6.81	6.38	6.69	26.72	5.05
	Cadets	22	6.86	6.55	6.64	6.86	26.91	5.24
SOAR	Instructors	32	6.13	6.37	6.19	6.16	24.84	5.48
	Cadets	22	6.18	6.23	6.27	6.36	25.05	5.19
DESIDE	Instructors	32	6.84	6.91	6.59	6.56	26.90	5.53
	Cadets	22	6.45	6.59	6.36	6.55	25.95	5.14

3.4 Discussion

In tactical environments, some of the decisions that must be made by fighter pilots can be considered as part of standard operating procedures but military pilots are also confronted with many problems that occur in continually changing situations that do not have a single best solution. Any decision made in the cockpit under circumstances of ambiguity is tempered by the task to be achieved (Prince & Salas, 1993). To make rapid decisions expert pilots make decisions using a holistic process involving situation recognition and pattern matching. Within this framework, pilots' situation awareness becomes the driving factor in the decision-making process. For the novice pilot, who often operates using very different decision-making strategies, understanding the situation frequently poses the major portion of their task (Klein, 1993b). In general, military aviation training organizations do not have specific methods or techniques for decision-making instruction during ab-initio training. The ability to make decisions in the air has often been regarded as by-product of flying experience rather than training. The data obtained in this research, however, suggests that the SHOR and DESIDE ADM mnemonic-based methods may be suitable as a basis for providing training which will be applicable for covering all six basic types of decision.

3.4.1 The Strengths of Different ADM Training Mnemonics in Different Tactical Scenarios

SHOR was developed for use in U.S. Air Force tactical command and control scenarios, where decisions were likely to be made under high pressure and within severe time constraints. These situations involve making near-real-time decisions involving threat warning and rescheduling, and will often require dynamic modifications to plans (Wohl, 1981). This research found that if instructor pilots thought that they were under time pressure they tended to rate SHOR as being most suitable the mnemonic method (see table 3.2). The contents of SHOR match the requirements of the scenarios requiring urgent decisions. As SHOR is basically an extension of the stimulus-response (S-R) paradigm of classical behaviourist psychology, it explicitly addresses the requirement to deal with two aspects of uncertainty in the decision-making process; information input uncertainty (relating to hypothesis generation and evaluation) and consequence-of-action uncertainty (which creates the requirement for option generation and evaluation) (Wohl, 1981). SHOR is able to promote quick responses in a time-limited situation and it also corresponds to the basic principles of briefing during tactical training. This may well explain why SHOR was rated more favorably than the other mnemonic methods in the recognition-primed decision-making scenario.

SHOR was also rated as the most suitable ADM mnemonic for making decisions in the 'go/no go decisions' scenario by cadet pilots, and in the 'recognition-primed decision'; 'resource management decisions'; and 'non-diagnostic procedural decisions' scenarios by instructor pilots, although SHOR showed no significant differences with other mnemonic-based methods in both the 'go/no go decisions' and 'resource management decisions' scenarios (see table 3.9). The qualitative data from both instructor pilots and cadet pilots also revealed that the four steps in SHOR fulfilled the requirements to deal with time-limited, urgent situations. It has simple steps with high applicability; it is easy to practice and it promotes the logical procedures required for safe action (table 3.3). PASS and SOAR did not receive such high ratings as SHOR but the qualitative comments received regarded both methods as having some strengths in promoting situation awareness, analysis of risk and were both useful when a quick response was required. SOAR was regarded by instructors as being good in encouraging pilots to re-evaluate their decisions after they had made their initial actions, and the best mnemonic in the 'recognition-primed decision' scenario by cadet pilots.

Table 3.9 Summary of rankings of the five ADM mnemonic methods across the six decision making scenarios broken down by Instructor pilots and Cadet pilots

Mnemonics	Respondents	Go/no go decision	Recognition -primed decision	Response selection decision	Resource management decision	Non-diagnostic procedural decision	Creative problem -solving
SHOR	**Instructors**	2	**1**	4	**1**	**1**	5
	Cadets	**1**	3	5	4	5	2
PASS	**Instructors**	**1**	3	2	5	2	3
	Cadets	4	2	4	4	2	4
FOR-DEC	**Instructors**	4	5	5	3	4	2
	Cadets	3	4	2	**1**	4	**1**
SOAR	**Instructors**	5	2	3	4	3	4
	Cadets	2	**1**	3	2	3	5
DESIDE	**Instructors**	3	4	**1**	2	5	**1**
	Cadets	5	5	**1**	3	**1**	2

DESIDE gained significantly superior suitability ratings by cadet pilots in the 'response selection decisions' and 'non-diagnostic procedural decision' scenarios. It was also rated by instructors as the best mnemonic method in the 'response selection decisions' and 'creative problem solving' scenarios (see table 3.9). This type of scenario is not an urgent tactical situation and has no immediately dangerous threats (although some of the qualitative comments from less experience cadet pilots would suggest otherwise: see table 3.7). Pilots have time (15 minutes in the bingo fuel scenario and nine minutes in the generator failure scenario) to think thoroughly about the alternative actions for safe operations. Murray (1997) suggested that the DESIDE mnemonic-based decision making method was a practical approach for assisting pilots when making decisions in such situations. The respondents in this study also indicated that when they would prefer to consider their options more fully (if they have enough time to do so), they regarded the DESIDE mnemonic-based ADM method as being the most suitable. DESIDE was also rated as the best decision-making mnemonic by both instructors and cadets for response selection decisions (see table 3.4) although there were no significant differences with the other mnemonic-based methods in this non-urgent scenario.

The qualitative data also showed that this method had suitable characteristics for dealing with non-urgent situations. It was rated highly for situation assessment, risk management, and applicability. It was thought to be comprehensive and thorough; clear about how to identify the safest actions; and it also had a logical order and was easy to remember (see table 3.7). However, it did require much more time to perform this analysis and produce a response. Instructor pilots advised that practicing DESIDE in the simulator was extremely important before attempting to apply it in a real life situation. The other six-step mnemonic method, FOR-DEC, was regarded as having similar strengths but again, only in non-time pressured situations. FOR-DEC was rated by cadet pilots as the best ADM mnemonic–based decision making method for promoting good resource management decisions (e.g. in the 'no joy for 2 versus 2 air intercept' scenario and in the 'generator failure' scenario) as would be expected of a methodology originally developed to promote good CRM.

The qualitative data elicited from the instructor pilots' showed that DESIDE has characteristics to deal with non-urgent situations as a result of its good situation assessment and risk management characteristics; it was thought that it prompted a comprehensive approach in terms of the number of factors that it encompassed in the decision making process; it was regarded as providing a specific and clear approach to analyze a situation and it possessed a logical order that was easy to remember. However, it did require more time to undertake the required steps and analyze and respond to the changing situation.

3.4.2 Critical Issues Affecting the Rating to ADM Mnemonics

The numeric data showed that instructor pilots and cadet pilots had no differences in their opinions about the overall suitability of the five ADM mnemonics as a basis for decision-making training across the six types of decision-making scenarios. However, this should not be taken to imply that experience has no effect on the quality of decision-making. There were however, significant differences in the ratings of suitability of the ADM mnemonics within certain decision-making scenarios. The critical issue affecting pilots' ratings of suitability was 'the perception of urgency'. As Fischer, Orasanu, & Wich (1995) suggested, perceived risk and time pressure may provoke an immediate response irrespective of if the problem was fully understood. Minimal risk levels and time constraints, in contrast, permit additional diagnostic actions or the further deliberation of options. This research found that if pilots thought that they were under time pressure they tended to rate the SHOR mnemonic as being most suitable. Otherwise, if not under such pressure, pilots would prefer to consider their options more fully and regarded the DESIDE mnemonic as being more suitable for decision-making training.

However, it is very interesting to know the definition of 'the perception of urgency' as it potentially has three different dimensions: available time, aspects of physical environment and uncertainty. For example, some pilots defined 'scenario six, both generators failure during tactical manoeuvre' as not being an 'urgent situation' as backup power was available for a further nine minutes. However, other pilots defined it as 'very urgent', because no one knows what's going to follow this failure in the next few seconds? Another example was the 'response selection scenario' where No.4 lost his leader in cloud during a tactical formation. Some pilots defined it as an urgent situation as the distance between the fighters' wingtips was only three feet. However, some pilots defined it as non-urgent for the SOPs had detailed descriptions of how to deal with the situation. In a third example, some pilots defined the 'non-diagnostic procedural scenario, bingo fuel in bad weather' as an urgent situation as a result of the uncertainty induced by the deteriorating environment. In contrast some pilots regarded it as a normal situation as there was still enough fuel to land at a diversionary airfield with sufficient time.

3.4.3 The Differences between Experts and Novices

Instructor pilots consistently selected SHOR as the best mnemonic-based decision making method in the recognition-primed decision, resource management decision and non-diagnostic procedural decision scenarios, all of which were urgent, potentially high risk, time-critical situations and required prompt actions. The instructor pilots' comments suggested that SHOR had the required characteristics to deal with urgent situations as it promoted quick responses. It was simple and easy to remember; it fitted the constraints inherent in time-limited and critical situations; it matched the general format of a pre-flight briefing; it was easy to put into practice; and it was thought that its logical procedures promoted safe action. Instructors were also consistent in selecting DESIDE as the best mnemonic for response selection decisions and creative problem solving decisions which were less urgent.

On the other hand, cadet pilots exhibited little consistency when assessing the suitability of the ADM mnemonic methods in the six different decision-making scenarios, selecting SHOR (for go/no go decisions), SOAR (for recognition-primed decisions), FOR-DEC (for resource management decisions and creative problem-solving), and DESIDE (for response selection decisions and non-diagnostic procedural decisions – see summary in table 3.9).

The numeric data showed that there were no significant differences between instructor and cadet pilots concerning the overall suitability of the ADM mnemonic methods as a basis for decision-making training across the six types of decision-making scenario. There were however, differences in the qualitative comments regarding the suitability of the ADM mnemonics between instructors and cadet pilots. These differences between instructors and cadets may further be explained by Chase and Simon's (1973) finding that experts organize knowledge about their domain into semantically meaningful units in long-term memory and that these units differ from those formed by novices. Also, expert knowledge in long-term memory is pattern indexed, and this pattern indexing is organized to facilitate achievement of domain-specific goals.

3.5 Summary

Orasanu (1993) suggested that the six basic types of decisions each impose different demands on the decision-maker and require different approaches. This research proposes that just two ADM training mnemonics form a suitable basis for decision-making training that encompass the requirements for these six basic decision making situations. SHOR was rated as being the best ADM mnemonic method in time-limited and critical, urgent situations; DESIDE was regarded as superior for knowledge-based decisions which required more comprehensive considerations but also had time available to do so. The qualitative differences in the ratings of the suitability of ADM mnemonics between experts and novices was probably a result of hazard perception. To optimize the effectiveness of decision-making training, it is suggested that it will be necessary to deliver instruction using both the SHOR and DESIDE ADM mnemonic-based methods and also provide advice concerning which approach is most suitable in which situations in the tactical environment.

The principal limitation of the present study was that it only elicited instructor and cadet pilots' opinions about the efficacy of these decision-making techniques. As a result, research needs to be undertaken to produce empirical performance data to establish if training in the use of ADM mnemonic-based methods such as SHOR and DESIDE can actually improve pilots' in-flight decision-making. These data are necessary to verify the opinions of the instructor pilots elicited in this study. The following study three corresponds to phases four and five (implement and control) of the IPISD model for training construction and evaluation. This further study needs to justify the effectiveness of ADM training interventions based on SHOR and DESIDE mnemonics methods across all different types of decision-making scenarios encountered in tactical environments. The following study was concerned with evaluating the effectiveness of the ADM training program subsequently derived using performance data obtained in a full-flight simulator. The cognitive processes employed by pilots were also investigated in a series of pencil-and-paper basd tests.

CHAPTER IV

Evaluation the Effectiveness of the Aeronautical Decision-making Training Intervention for Military Pilots

4.1 Introduction

Military pilots generally make critical decisions in dynamic tactical situations under time pressure and using ambiguous information. The ability to make timely effective decisions is an essential competence required of all military pilots, but until recently decision making training remained unstructured. Military pilots must perform a wide range of tasks in addition to flying the aircraft safely. These tasks may include intercepting offensive aircraft, delivering weapons, troops or equipment, in addition to flying the aircraft. Therefore, military pilots must learn to make decisions related to mission performance in addition to those decisions related to flying the aircraft (Kaempf & Orasanu, 1997).

The quality of decision-making has been treated as a by-product of flight experience (Buch & Diehl, 1984). Decision-making skills of military pilots are acquired through situation-specific training which incorporates an increasing variety of tactical environmental variables (David, 1997). There is a need for in-flight decision-making training to be addressed directly and to be incorporated into the tactical training programs (Li, Harris & Yu, 2005). At the present time, there is no training program for aeronautical decision-making for military pilots in existence either in the R.O.C. Air Force or elsewhere around the world, although research had recognized the need for training aeronautical decision-making (Klein, 1993; Orasanu, 1993; Prince & Salas, 1997).

There are many theoretical frameworks describing the processes and procedures concerned with aeronautical decision making (ADM) and many mnemonics have been promulgated in recent years to support what is thought to be decision-making 'best practice' (e.g. Wohl, 1981; Maher, 1989; Klein & Woods, 1993; Hormann,1995; Oldaker, 1996; Jensen, 1997; David, 1997; Murray, 1997; Orasanu, 1997; Jensen & Hunter, 2002; O'Hare, 2003). However, while a great deal of research has suggested that ADM is trainable (Endsley, 1993; Klein, 1993 &1997; Orasanu, 1993; Prince & Salas, 1997; Li & Harris, 2005), there is a lack of hard empirical research investigating the efficiency of these ADM mnemonics in flight.

4.1.1 The Critical Components in Decision-making Process

ADM is defined by FAA (1991) as 'a systematic approach to the mental process used by aircraft pilots to consistently determine the best course of action in response to a given set of circumstances' (Hunter, 2003). This definition includes both process and outcome, and is clearly similar in scope and meaning to Jensen's (1995) definition of judgment as 'the mental process that pilots use in making decision'. Flying an advanced fighter performing a tactical mission has increased the demands on pilots' cognitive abilities as the complexity of systems inside cockpit and the dynamic situations outside the cockpit has also increased. As described in the previous chapter, Endsley (1997) defines situation awareness (SA) as 'the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the future'. Situation awareness and decision-making are indispensable for flight safety and are closely related. In both processes, situation assessment is fundamental. Situation assessment has been described as the process by which the state of situation awareness is achieved and has been identified as a critical decision-making component (Endsley & Bolstad, 1994). Situation assessment is a precursor for situation awareness, which is itself the precursor for all tasks of decision-making (Prince & Salas, 1997).

For military pilots operating in a hostile environment, the normal hazards of aviation are compounded by the enemy's intent for the destruction of the aircraft. It was also noted in the previous chapter that Fischer, Orasanu, & Wich (1995) suggested risk and time pressure are situational variables that further constrain the decision process, as risk and time pressures may dictate an immediate response whether or not the problem was fully understood. Minimal risk levels and time constraints, in contrast, permit additional diagnostic actions or the deliberation of options. Jensen, Guilke & Tigner (1997) suggested that risk management should be a key part of the decision-making process. Orasanu, Davison & Fischer (2001) also recommended that to manage threats, pilots must first assess the risks associated with them. Risk assessment feeds into decision making in two ways: during the assessment of the precipitating threats and in evaluating potential courses of action. Janis and Mann (1977) proposed that a good decision-making process is one in which the decision maker successfully accomplishes a series of tasks involving the collection of information about a wide range of alternatives, the careful assessment of the risks and benefits of each course of action, and the preparation of contingency plans for dealing with known risks. Slovic (1987) observed that risk perception depends on the experience people have with a situation; their personal vulnerability; and the level of control they have over a situation. The time frame of the risk was also important.

Time pressure has several obvious but important implications for decision-making. As noted in the previous study, decision makers will often experience high levels of stress; and, their thinking will shift, characteristically in the direction of using less complicated reasoning strategies (Payne, Bettman, & Johnson, 1988). Also, research on the use of probabilistic cues has demonstrated that decision makers focus on the most salient cues and ignore other critical, less obvious information, especially when under time pressure (Wickens & Flach, 1988). Military pilots often make important decisions using ambiguous information under great risk and time pressure. Therefore, decision aids and training are required to provide pilots with the necessary skills to make quick situation assessments (Kaempf & Orasanu, 1997).

When evaluating decision-making efficacy, Baron and Hershey (1988) suggested that the study of 'outcome' bias on decision evaluation shows the tendency of people to assess the correctness of their decision-making based on the outcome of the decision. However, good decisions can lead to bad outcomes (and vice versa). Decision makers cannot infallibly be graded by their results (Brown, Kahr, & Peterson, 1974). A good decision cannot guarantee a good outcome. All in-flight decisions are made under uncertainty. Evaluating a decision as good or not must depend on the stakes and the probability, not on the outcome. Hence, in this study the evaluation of the effectiveness of decision-making training is based on using situation assessment and risk management measures. Rather than assessing the outcomes of the decisions made.

4.1.2 The History of ADM Training

Means, Salas, Crandall, and Jacobs (1993) advised that it is important to give pilots pattern recognition exercises during training. A flight simulator can offer great advantages for pattern recognition presenting simulated situations based around scenarios that are significant when making real-time decisions. They can provide scenarios that occur frequently during tactical maneuvers. A simulator offers the option of being able to provide many practice problems, designed to build up the recognition of patterns. Positive transfer of training can be expected the more the simulator duplicates the operation of the aircraft when performing a mission. The task of flying military aircraft requires part-task training on procedures, navigation, flying skills, and weapon delivery, each of which is practiced separately before being assembled into whole-task training. Knowing these goals enables training design to be directed more appropriately. Furthermore, if it is made clear how the design of a training course fits into the trainee's future job, such as training ADM for fighting, reconnaissance, escort or transportation missions, the learning motivation of trainee will be improved.

There are a number of strategies (often embodied in mnemonics or acronyms) that have been developed by researchers and used by pilots to guide and structure decision-making. The common aim of these techniques is to form a systematic approach to decision-making that should be less affected by the human nature and which should also reduce the cognitive work for pilots (O'Hare, 2003). Buch and Diehl (1984) found that judgment training produced significantly better decisions among civil aviation pilots in Canada. Connolly, Blackwell & Lester (1989) advised that pilot's decision-making skills could be significantly improved through the use of judgment training materials along with simulator practice. However, Orasanu (1993) has pointed out that there was no evidence to support the development of generic training techniques to improve all-purpose decision making skills, as there were different component skills involved in making six different basic types of decisions. As a result Orasanu (1993) suggested that it was unlikely that any one single training method could improve all decision-making, there were need different types of training for improving the quality of decision-making.

SHOR was rated as being the best ADM mnemonic in time-limited and critical, urgent situations, DESIDE was regarded as superior for knowledge-based decisions which required more comprehensive considerations but also had time available to do so (see previous Chapter). To optimize the effectiveness of decision-making training, it is suggested that instruction is provided using both the SHOR and DESIDE ADM mnemonic-based methods and also advice should be provided concerning which approach is most suitable in which situations in the tactical environment (Li & Harris, 2005).

4.1.3 Evaluating the Effectiveness of ADM Training

Kirkpatrick's (1976) hierarchy for training evaluation examines the impact of training interventions at four different levels: reactions, learning (attitudes and knowledge), behaviour, and organizational effects. The first of these levels is reactions. Reactions are concerned with how the participants respond to the training. These are important because while positive reactions do not ensure learning, a negative reaction almost certainly reduces the likelihood that this has taken place. Information about flight crew reactions are usually collected from questionnaires asking about satisfaction or enjoyment of the training course. The second level of evaluation is learning, and is concerned with whether the participants have acquired knowledge or have modified their attitudes or beliefs as a result of attending a training course. Learning can be measured in terms of changes in attitudes and/or knowledge. If these do not alter then it is unlikely changes in behaviour will occur. Attitudes can be measured with paper-based questionnaires. Knowledge can be assessed in a number of ways but again paper-based examinations are most frequently used. The third level of evaluation is behaviour. This involves assessing whether knowledge gained in training transfers to actual behaviours on the job. This is considered the most critical part of CRM evaluation so far because this is where changes in actual performance can be detected. The fourth level of evaluation is at the organizational level. This is concerned with whether the training has a beneficial impact on the organization itself. Therefore, for a CRM training program, the ultimate aim would be to produce tangible evidence of an improvement in safety and efficiency (Kirkpatrick, 1976 & 1998).

It is vital that training programs are assessed to determine if they are achieving their goals (FAA, 1993). O'Connor, Flin, & Fletcher (2002) suggested that there are a number of important reasons for evaluating the effects of training programs. They should be evaluated to determine if they meet stated goal of improving safety and efficiency; teach the appropriate knowledge, attitudes and skills in an ever-changing technology and risk environment; and to check that they produce a return on investment for their development and delivery costs. Patrick (1992) advised that there are several approaches to the evaluation of training that differ in terms of their aims, criteria, and methods. The traditional approach to evaluation has been to identify whether the training meets its training objectives, or if not, how the training program should be modified. The role of evaluation is therefore to correct and manage training design, and this is integral to the Instrumental System Development (ISD) approach. Feedback from evaluations may result in revision to the training objectives or training design. The criteria used for this type of evaluation concerns both the processes of training development and the products of training as manifested in performance at both the individual and organizational levels. In military aviation, Prince and Salas (2000) found that although CRM training did not show an effect on the pilots' attitudes, it did appear to increase their knowledge of teamwork principles. However, the problem with relying on subjective assessment is that the individual will be most influenced by whether they enjoyed the training, or by how well they felt they performed. Additionally, participants will only describe what can be verbalized, which results in information that cannot be verbalized being ignored.

4.1.4 Research Purposes

Simulator experiment was to assess the 'product' of ADM training. Pencil and paper tests were to provide insight into if the trainees were applying the correct procedures to reach a decision. The purposes of this research are to evaluate the effectiveness of an ADM training intervention based on the SHOR and DESIDE mnemonic methods across six basic decision-making scenarios in a tactical environment using a flight simulator-based experiment and pencil and paper tests. The pencil and paper trials analyzed pilots' cognitive 'processes', however, this research approach could not assess the real-time performance of pilots' in-flight decision-making, also not suitable for evaluating the dimension of 'response time' of pilots' decision-making performance. On the other hand, simulator trials can assess the 'products' of ADM performance including the situation assessment, risk management, and response time in real-time setting, however, they had limitations for analyzing pilots' cognitive processes.

4.2 Method

4.2.1 Participants

Forty-one male pilots from R.O.C. Air Force Tactical Training Wings participated in the study. The flying experience of participants was between 354 and 220 hours with an average of 292 hours. Participants were randomly divided into two groups, 21 pilots in experimental group (trained), and 20 pilots in control group (untrained).

4.2.2 Research Design

The experimental design was a mixed groups design, with two factors, one with repeated measures. Participants were randomly divided into two groups, an experimental group and a control group. Firstly, both groups participated in a pre-test for both trials in the flight simulator and the pencil and paper evaluations. After the pre-test trials, the experimental group attended a four hour "ADM Training Program for Military Pilots". The control group had no training intervention. Both groups participated in post-training performance trials to further evaluate their performance of in-flight decision-making (see table 4.1).

The main advantage of this design is that it takes into account the impact of individual characteristics such as flight experience, flight performance, cognitive ability and motor skill (Christensen, 1997), and it provides the highest level of control over the factors that impact upon subsequent performance. However, the difficulty is that there is often a need to control for variables that may occur as part of the intervention process, such as practice effect, memory effect or the placebo effect (Lloyd, Mayes, Manstead, Meudell, & Wagner, 1990). One strategy to overcome the effects of repeated measure is to employ a control group, as it provides for maximum control over these extraneous variables (Wiggins & Stevens, 1999).

Table 4.1 The experimental design for comparison of the effectiveness of training interventions

	Pre-test	**Training Intervention**	**Post-test**
Experimental Group (21 Subjects)	3 Simulator Trials & 6 Pencil and Paper Trials	Aeronautical Decision-making Training Programs for Military Pilots(4 hours)	3 Simulator Trials & 6 Pencil and Paper Trials
Control Group (20 Subjects)	3 Simulator Trials & 6 Pencil and Paper Trials	**No Intervention**	3 Simulator Trials & 6 Pencil and Paper Trials

4.2.2.1 Simulator Trials

As a result of the available time for using the flight simulator and the pilots' tight schedule for flight training time was limited. As a result only three different types of decision-making scenario were assessed in the simulator study. These were the scenarios requiring participants to make a recognition-primed decision, a non-diagnostic procedural decision and where they were required to engage in creative problem solving. Furthermore, previous research (Li & Harris, 2005a) had found that the ADM mnemonic methods trained were assessed as being particularly applicable in these three situations. The strength of conducting simulator trials was to evaluate the 'products' of pilot's decision-making performance on the simulator scenarios. However simulator trials can't evaluate the 'process' of pilot's decision-making, hence the use of pencil and paper tests of decision-making performance was added.

All trials were undertaken in the Northrop F-5E simulator from the R.O.C.A.F Tactical Wing. The F-5E simulator was equipped with six different Air Force visual databases which provided a realistic representation of the airfields and terrain within a 250 miles radius of Taiwan. The cockpit of F-5E simulator was exactly the same as the real F-5E fighter and it was capable of performing the whole range of different tactical manoeuvres. From the Instructor's control panel it was possible to program the simulator to meet a wide range of training requirements, including manipulating the weather, terrain characteristics, and other emergency situations.

4.2.2.2 Pencil and Paper Tests

After completing the three simulator trials, participants undertook a series of pencil and paper tests using all six scenarios; go/no go decisions, recognition-primed decisions, response selection decisions, resource management decisions, non-diagnostic procedural decision, and creative problem solving scenarios. The strength of pencil and paper tests is to investigate the 'processes' of pilot's decision-making on the paper scenarios. Participants were required to write down their decision-making process to deal with six different situations, what they perceived the situations to be and how they formed the strategies to solve the problems. When the pilot wrote down his decision-making and response to deal with the requirements of scenarios, it was possible to analyze the 'processes' of his decision-making strategies.

4.2.3 The Contents of ADM Training Program

Two ADM mnemonic methods, SHOR (Wohl, 1981) and DESIDE (Murray, 1997), that had been previously been assessed by instructor and cadet pilots as being the most applicable and having the potential to significantly improve the quality of military pilots' decision-making in study two (Li & Harris, 2005) formed the basis of the ADM training program. The training program commenced with an introduction to ADM theories (one hour), including the Recognition-Primed Decision Model of Rapid Decision Making (Klein, 1993); The ARTFUL Decision Maker: A Framework Model for Aeronautical Decision Making (O'Hare, 1992); Conflict-theory Decision Making Model (Janis & Mann, 1977); a Model of Situation Awareness in Dynamic Decision-making (Endsley, 1997); and the Decision Process Model (Orasanu, 1995). This was followed by a description of the content and method of the application of the SHOR and DESIDE ADM mnemonic-based methods (half an hour). Following this, participants practiced in the classroom the application of SHOR and DESIDE in flight situations exemplifying the six basic types of decision making scenario described by Orasanu (1993). These included go/no go decisions; recognition-primed decisions; response selection decisions; resource management decisions; non-diagnostic procedural decisions, and decisions requiring creative problem-solving (one and half hours). Finally, the application of ADM in military aviation was described and the participants undertaking the training were de-briefed (one hour). The ADM training program last for four hours in total.

4.2.4 The Development of Decision-making Scenarios for Pre-training and Post-training Evaluation Trials

To develop scenarios for the simulator trials and the pencil and paper trials, six focus groups were conducted, one for each scenario. Each comprised one human factors specialist and three senior instructor pilots. The purpose of these focus groups was to verify that the twelve scenarios, six scenarios for pre-training evaluation (see Appendix 8.2) and six scenarios for post-training evaluation (see Appendix 8.3) selected from the accidents and incidents database, corresponded to the appropriate six types of decision-making scenarios described by Orasanu (1993). These focus groups also ensured enough detail was available in both the simulator trials and the pencil and paper trials to evaluate the decision-making performance of the pilots. There were six different scenarios used in the pre-training and post-training evaluation to counteract the effects of practice. All the pre-training scenarios used were the same as those used in study 2.

4.2.4.1 Go/no go Decision Scenarios

Go/no go decisions are made under severe time pressure and involve considerable risk; the amount of thinking involved should be minimal.

Pre-training: F-5E No. 2 wingman has to make a decision as the No. 1 (Leader) abandons a tactical formation take-off at 145 knots.

Post-training: F-5E No. 2 wingman practicing the tactical formation training. During the take off run with the throttles at maximum, No.1 (leader) suddenly slants seriously towards the No.2.

4.2.4.2 Recognition-Primed Decision Scenarios

Recognition-primed decisions are defined by Orasanu (1993) as the need to recognize situational patterns that serve as inputs to condition-action rules, but which also require the decision maker to learn the response side of the rule and its link to the condition.

Pre-training: F-5E right engine fails *as a result of Foreign Object Damage just as the nose gear leaves the ground at speed 165-knots.*

Post-training: F-5E solo, after taking off at 500 feet, pilot hears two unusual sounds from the engines and feels the aircraft shake. Engine EGT (Exhaust Gas Temperature) is increased, and RPM decreased.

4.2.4.3 Response Selection Decision Scenarios

Response selection decisions require a single option to be selected from a set; pilots must recognize multiple options and evaluate them in terms of how well they satisfy the goals and meet constraints.

Pre-training: No. 4 wingman in a tactical formation of F-5Es is required to make a decision when No. 1 (Leader) becomes missing in cloud during formation flight (3 feet distance between wing tips for the four fighters).

Post-training: F-5E leader while maintaining easy formation with No. 2 on the left, at 13000 feet, the GCI (Ground Control Intercept) reports an unidentified aircraft at one o'clock and 5 miles away. At the same time No.2 visuals an airliner in front and head-on 3 miles away with same altitude and approaching fast (leader had no orders).

4.2.4.4 Resource Management Decision Scenarios

Resource management decisions involve assessing the *relative* priorities of various tasks, especially critical ones. Skills relevant to this type of decision include estimation of the time required to complete various tasks, knowledge of interdependencies among tasks, and scheduling strategies.

Pre-training: F-5E leader of four aircraft needs to make a decision for the No.3 and No. 4 aircraft when a 'no joy' call (no visual contact with No. 1 and No. 2) is made and No. 2 calls 'one opposing target approaching on 12:30 o'clock with same altitude'. This occurs during practice of a 2 versus 2 Engagement (Air Combat Manoeuvre).

Post-training: Leader and No.2 is practicing BFM (Basic Fighting Manoeuvres) for a gunshot attack, the distance between No. 2 and the leader is only 500 feet, the angle off is over 90 degrees. The possibility of a mid-air collision is high as both aircraft are at 480 knots and same altitude.

4.2.4.5 Non-diagnostic Procedural Decision Scenarios

Non-diagnostic procedural decisions involve a number of cues falling into a category with no prescribed response. The nature of this problem is unclear and many different types of ambiguous cues may also signal potentially dangerous conditions.

Pre-training: Both the leader and wingman in a formation of F-5Es are unable to land at home-base in a 'bingo' (low fuel) situation during instrument flight in bad weather.

Post-training: F-5E is finishing the BFM training, the GCI reports that home base weather is worsening. Surplus fuel is down to only 1400 lb. The pilot asks for weather conditions at alternative airports.

4.2.4.6 Creative Problem Solving Scenarios

Creative problem-solving are the most complex decision-making scenarios, as they involve both diagnosis to determine the nature of the situation and response generation. Pilots must determine what their goals are, develop a plan and candidate strategies, and evaluate these strategies and planned actions based on projections of likely outcomes.

Pre-training: When flying an F-5F both left and right generator warning lights are active during a tactical manoeuvre.

Post-training: When an F-5E is lowering the landing gear while on the down-wind leg the landing gear shaft warning light illuminates, indicating the nose landing gear is abnormal.

4.2.5 Procedure

4.2.5.1 Procedure for Simulator trials

Each participant undertook two sets of trials in the simulator encompassing three different decision-making scenarios; recognition-primed decisions, non-diagnostic decisions and creative problem solving. One set of trials were undertaken pre ADM training and the second set of trials were undertaken after the experimental group had received the four hours ADM training course. To negate practice effects, different (but equivalent) simulator scenarios were used pre- and post ADM training for both groups. To eliminate order effects, the three scenarios were presented in a randomized order in both the pre- and post-training trials.

During the flight trials participants were required to provide a running commentary concerning their perception of the flight situation and how they were forming their strategies to deal with the problem. No participants were aware of the overall design of the research or the scenarios for the simulator trails. After each simulator trial, participants undertook a structured de-briefing concerning their performance and the pilots described the decision-making process employed and the factors underpinning their decision.

4.2.5.2 Procedure for Pencil and Paper Trials

Both the experimental (trained) and control (untrained) groups undertook an initial set of pencil and paper based evaluations where they were required to describe how they would deal with each of the problems described in above pre-training decision making scenarios. These evaluations were simply in the form of narrative-based responses. After these initial tests the experimental group attended a four-hour 'ADM Training Program for Military Pilots'. The Control group had no such training. Both groups then participated in a further set of pencil and paper evaluations. As in the simulator trials, to eliminate order effects, the six scenarios were presented in a randomized order in both the pre- and post-training trials.

4.2.6 Measures

Pilots' performance was evaluated on three dimensions (situation assessment, risk management and response time) by a professional simulator instructor. These dimensions were derived from the earlier study (study 2: Li and Harris, 2005b) to select the most appropriate ADM training mnemonic methods. Each aspect of performance was rated using a nine-point Likert-type scale (the best performance with the highest score of 9 and the poorest performance with the lowest score of 1, or in the case of the dimension of response time a score of 1 indicating the fastest and, 9 is the slowest).

To enhance the reliability of the performance evaluations, the same simulator instructor evaluated trainee performance on all occasions. The instructor was trained by an aviation human factors specialist in the required manner to evaluate performance with regard to their situation assessment, risk management and speed of response. For the evaluation of both Situation Assessment and Risk Management performance in the simulator trials, a list of key performance factors was developed for each scenario based upon the tactical training and flight simulator training manuals. The steps that should be undertaken and sources of information that should be considered in each circumstance were listed, these being factors underlying Situation Assessment performance. For example in the scenario of an engine failure at take-off, the pilot needs to be aware of (1) engine temperature and pressure, (2) airspeed, (3) attitude and altitude, (4) left or right engine problem, (5) the length of available runway, (6) other aircraft nearby, and (7) the availability of the safety net. The more components that pilots mentioned the higher their score for Situation Assessment. Emphasis on the risk management dimension was placed upon the generation and analysis of options and the quality of reasoning underlying the pilot's final decision based specifically on the control of risk and the probability of dealing with that risk successfully. Using the same example of an engine failure on take-off, the pilot has to conduct a mental simulation to minimize the risk for his final decision of (1) an aborted take-off, (2) a single engine take-off, or (3) ejection. These ratings were again based upon the verbal commentary provided by the pilots. The more suitable actions taken by pilots to minimize the risk, the higher their score was for Risk Management. From the configuation of the control panel on the flight simulator, the instructor could also evaluate participants' Response Time to each scenario.

The same types of measure were used to evaluate the pilots' decision-making processes in the pencil and paper tests (with the exception of the rating of response time). The narrative responses describing the process by which the participants would arrive at their decision were evaluated by a flight instructor with regard to their situation assessment and risk management performance. As in the simulator assessments, to enhance the reliability of the measures, the same instructor evaluated trainee performance on all occasions. The instructor was trained by an aviation human factors specialist to evaluate performance in the required manner. For the evaluation of both Situation Assessment and Risk Management performance in the narrative answers produced, a list of key performance factors taken from the tactical training manuals was derived for each scenario. The steps that should be undertaken and sources of information that should be interrogated in each circumstance were listed, these being factors underlying Situation Assessment performance in particular. Emphasis on the risk management dimension was placed upon the generation and analysis of options and the quality of reasoning underlying the pilot's final decision based specifically on the control of risk and probability of dealt with risk successfully. Perfect performance was awarded with the highest score of 9 and the poorest performance with the lowest score of 1.

4.2.7 Ethical Approval

This research program was approved by the Ethics committee of Cranfield University. This committee operates to the principles prescribed by the British Psychological Society (the UK professional body for psychologists). Participants were volunteers and informed of the purpose of the study prior to participating.

4.3 Results

4.3.1 Simulator Trials

In total, 246 trials assessing pilots' ADM performance on the flight simulator were undertaken, 123 trials prior to the experimental group undertaking the ADM training and the same number after the training course had been delivered. One hundred and twenty-six trials were undertaken by the experimental (trained) group and 120 by the control (untrained) group.

4.3.1.1 Recognition-Primed Decisions

There was an effect verging on statistical significance with regard to pilot performance before and after the decision-making training on the dimension of situation assessment ($F_{1,39}=3.520$; $p=0.068$). This suggested that pilots' situation assessment was rated as having improved on the second trial (see table 4.2). The group that had received ADM training also significantly outperformed the group that had not received training on situation assessment ($F_{1,39}=6.904$; $p=0.012$). The interaction term between the trained/untrained group and before training trial/after training trial was non-significant ($F_{1,39}=1.735$; $p=0.195$).

There was a significant difference on the dimension of risk management before and after decision-making training ($F_{1,39}=12.467$; $p=0.001$). This also indicated that pilots' performance was rated as being superior during the second trial. There was a further significant difference in performance between the trained and untrained group

($F_{1,39}=6.736$; $p=0.013$) with the group that had received ADM training outperforming the group that had not received training (see table 4.2). As before, there was no significant interaction between the trained/untrained group and trial ($F_{1,39}=2.248$; $p=0.142$).

There was no significant difference on rated speed of response between trials ($F_{1,39}=2.778$; $p=0.104$). There was also no difference between the trained and untrained group ($F_{1,39}=0.013$; $p=0.910$) (see table 4.2). There was, however, a result verging on significant with respect to the interaction term ($F_{1,39}=3.890$; $p=0.056$). The group that had received ADM training tended to exhibit longer response times in the second trial compared to the untrained group (see figure 4.1).

Table 4.2 Means and Standard Deviations in performance scores in the Recognition-primed decision-making scenario, broken down by main effect, on the three dimensions of situation awareness, risk management, and response time

Recognition-primed decisions		**Group**	**N**	**Mean**	**Standard deviation**
Situation assessment	Pre-test	Trained	21	5.00	1.703
		Untrained	20	4.35	1.599
	Post-test	Trained	21	5.86	1.526
		Untrained	20	4.50	1.051
Risk management	Pre-test	Trained	21	4.48	1.537
		Untrained	20	4.05	0.945
	Post-test	Trained	21	5.71	1.309
		Untrained	20	4.55	1.146
Response time	Pre-test	Trained	21	4.67	1.592
		Untrained	20	5.35	1.872
	Post-test	Trained	21	5.86	0.964
		Untrained	20	5.25	1.446

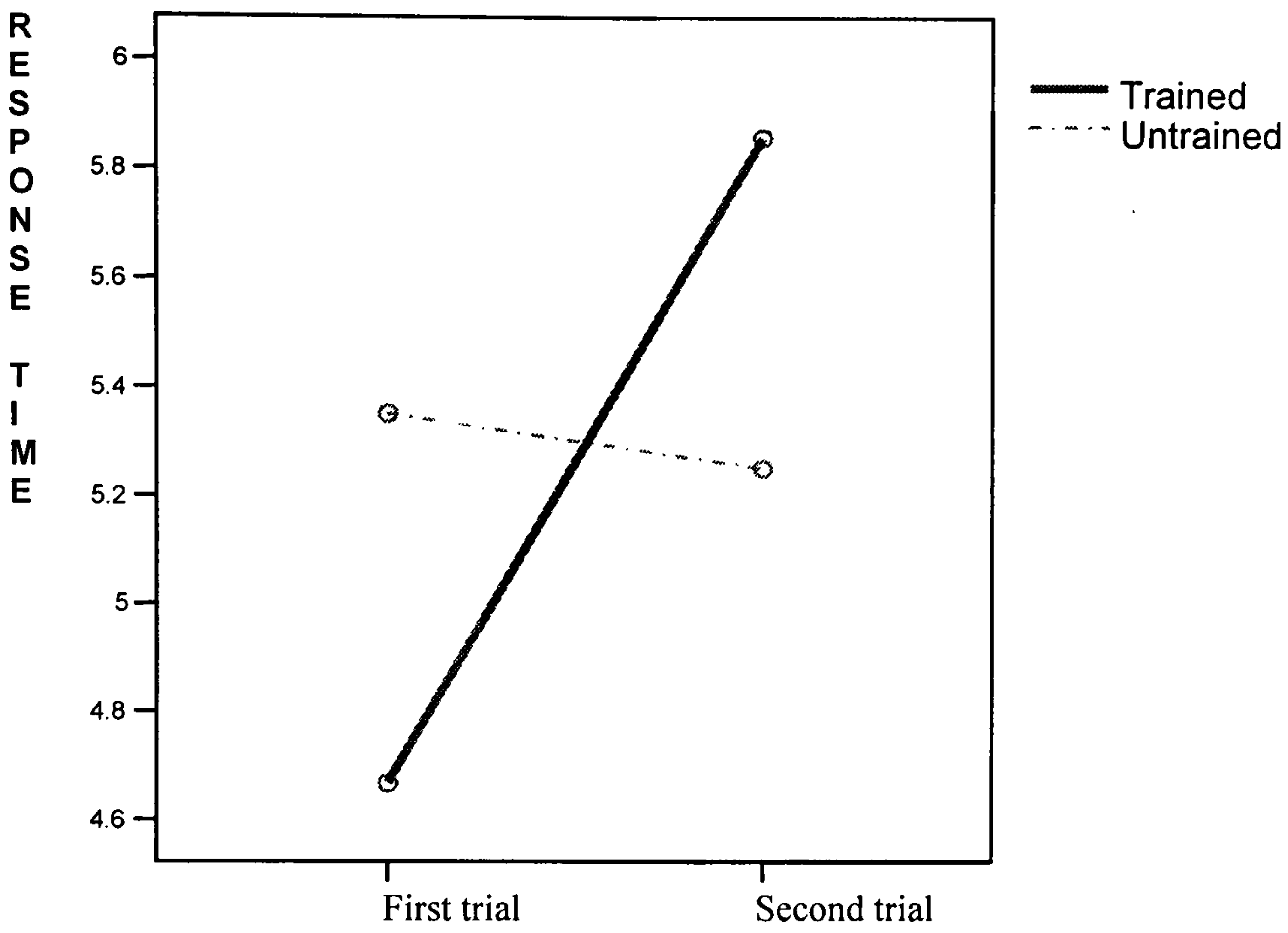


Figure 4.1 The interaction between the trained/untrained group and trial for response time in the Recognition-primed decision-making scenario

4.3.1.2 Non-diagnostic Procedural Decisions

There was a significant difference in performance on the dimension of situation assessment before and after decision-making training ($F_{1,39}$=8.216; p=0.007). Pilots' performance was significantly better during the second trial (see table 4.4). There was no significant difference between the trained and untrained groups ($F_{1,39}$=2.484; p=0.123). However, there was a significant interaction term ($F_{1,39}$=4.237; p=0.046). The group that had received ADM training showed significantly greater gains in situation assessment performance in the second trial compared to the untrained group (see figure 4.2).

There was also a significant difference on the dimension of risk management before and after decision-making training ($F_{1,39}$=6.761; p=0.013). The results indicated pilots' performance was significantly better on the second trial. There was a result tending toward statistical significance between the trained and untrained groups ($F_{1,39}=3.316$; p=0.076) with the group that had received ADM training exhibiting better performance than the group that had not (see table 4.3). Furthermore, there was a significant interaction between the trained/untrained group and trial ($F_{1,39}=7.743$; p=0.008). The group that had received ADM training showed significantly greater gains in performance on the second trial compared to the untrained group (see figure 4.3).

There was a significant difference on the dimension of rated speed of response between trials ($F_{1,39}=9.369$; p=0.004). It showed the pilots' response times during the second trial were significantly longer than the first trial. However, there was no significant difference between the trained and untrained group ($F_{1,39}=1.753$; p=0.193) in this respect and there was also no significant interaction term ($F_{1,39}=0.692$; p=0.411) (see table 4.3).

Table 4.3 Means and Standard Deviations in performance scores in the Non-diagnostic procedural decision-making scenario, broken down by main effect, on the three dimensions of situation awareness, risk management, and response time

Non-diagnostic procedural decisions		**Group**	**N**	**Mean**	**Standard deviation**
Situation assessment	Pre-test	Trained	21	4.38	1.774
		Untrained	20	4.55	0.826
	Post-test	Trained	21	5.90	1.480
		Untrained	20	4.80	1.196
Risk management	Pre-test	Trained	21	4.29	1.454
		Untrained	20	4.55	0.826
	Post-test	Trained	21	5.76	1.375
		Untrained	20	4.50	1.192
Response time	Pre-test	Trained	21	4.33	1.494
		Untrained	20	4.20	0.894
	Post-test	Trained	21	5.38	1.244
		Untrained	20	4.80	1.152

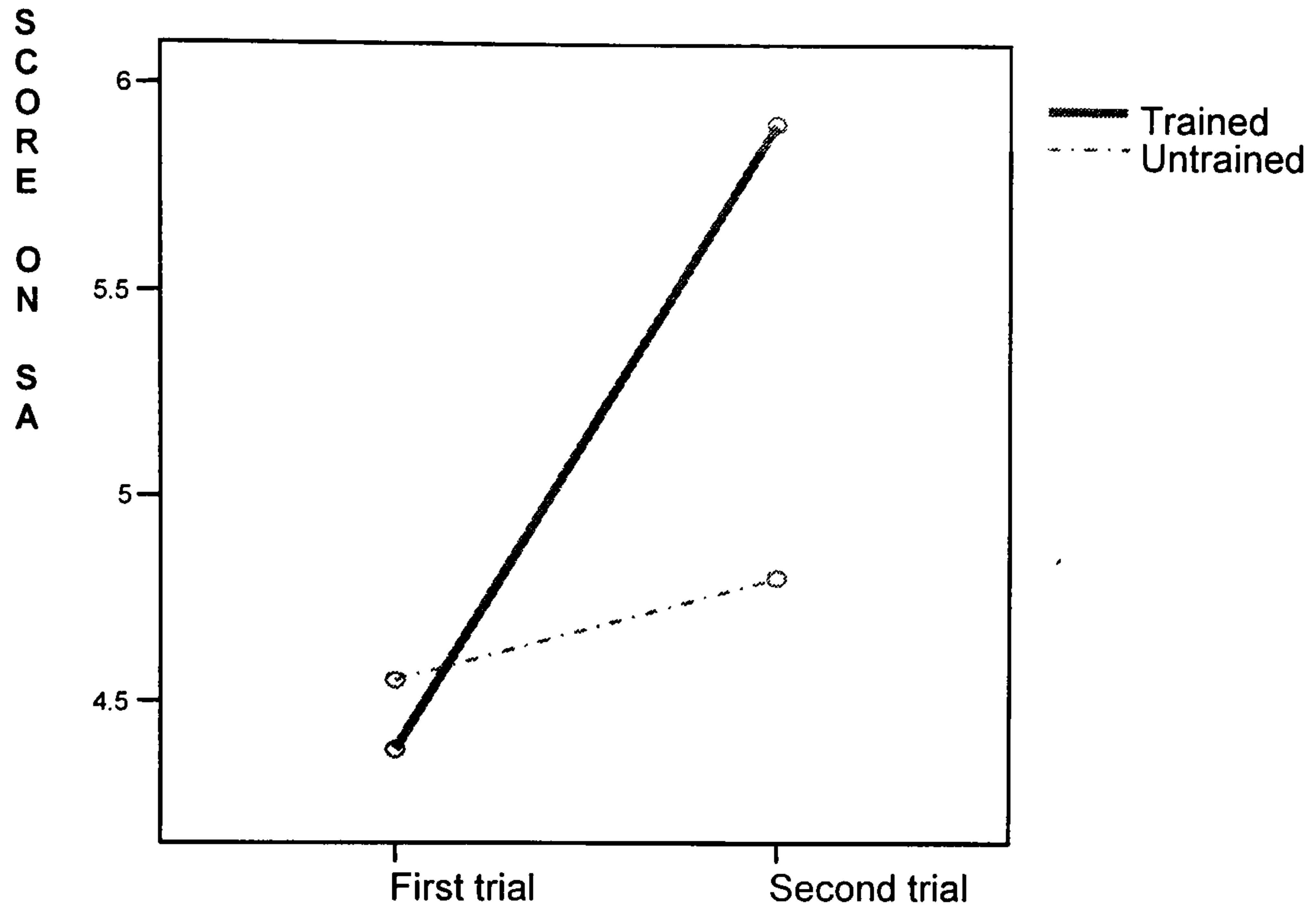


Figure 4.2 The interaction between the trained/untrained group and trial for situation assessment in the Non-diagnostic procedural decision-making scenario

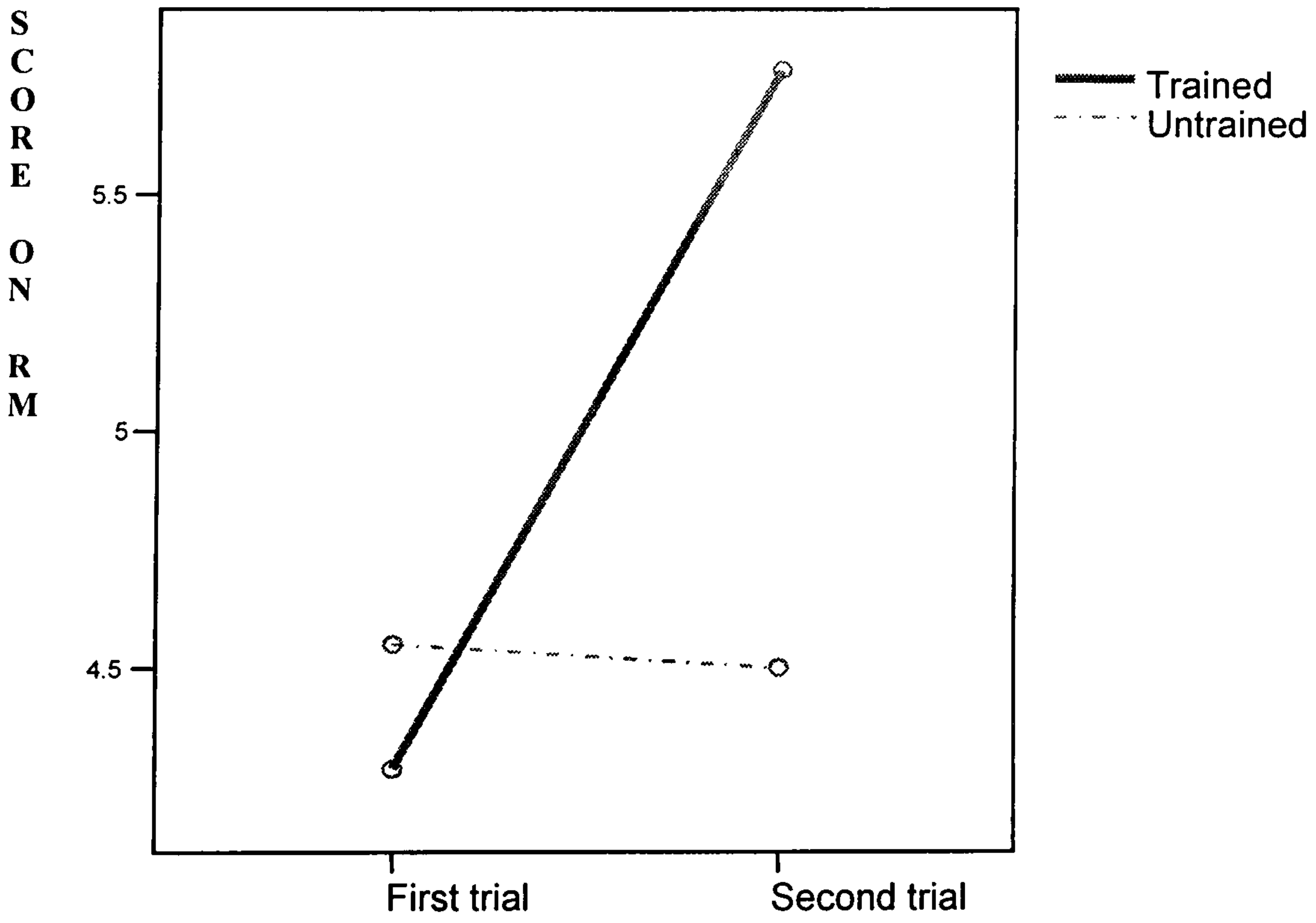


Figure 4.3 The interaction between the trained/untrained group and trial for risk management in the Non-diagnostic procedural decision-making scenario

4.3.1.3 Creative problem-solving

There was a significant difference on the dimension of situation assessment between the first and second trials ($F_{1,39}$=5.364; p=0.026). The results showed that pilots' situation assessment was significantly better during the second trial. The result examining the main effect of training was verging on significance, suggesting that the group that received ADM training performed better ($F_{1,39}$=3.063; p=0.088) (see table 4.4). Similarly, there was also a result approaching significance for the interaction term ($F_{1,39}$=2.993; p=0.092). The group that had received ADM training again showed a trend toward better performance in the second set of trials after training compared to the untrained group (see figure 4.4).

There was a significant difference in performance on the dimension of risk management with respect to trial ($F_{1,39}$=6.617; p=0.014). Pilots' performance on this dimension was superior during the second set of trials. There was no significant difference in this regard between the trained and untrained group ($F_{1,39}$=0.669; p=0.418) (see table 4.4). However, there was a significant interaction term between the trained/untrained group and trial ($F_{1,39}$=4.278; p=0.045). The group that had received ADM training showed greater gains in performance in the second trial (after training) compared to the untrained group (see figure 4.5).

There was a result verging on a significant difference on the dimension of response time ($F_{1,39}$=3.185; p=0.082). It indicated that pilots' response times during the second trial were longer than the first trial. Also, there was a significant difference between the trained and untrained group ($F_{1,39}$=6.164; p=0.017). The group that had received ADM training tended to be rated as having significantly longer response times than the group that had not received training (see table 4.4). There was no significant interaction term between the main effects ($F_{1,39}=2.132$; $p=0.152$).

Table 4.4 Means and Standard Deviations in performance scores in the Creative problem-solving scenario, broken down by main effect, on the three dimensions of situation awareness, risk management, and response time

Creative problem-solving		**Group**	**N**	**Mean**	**Standard deviation**
Situation assessment	Pre-test	Trained	21	5.05	1.830
		Non-trained	20	5.00	1.686
	Post-test	Trained	21	6.43	1.076
		Non-trained	20	5.20	1.704
Risk management	Pre-test	Trained	21	4.86	1.682
		Non-trained	20	5.15	1.843
	Post-test	Trained	21	6.24	1.375
		Non-trained	20	5.30	1.380
Response time	Pre-test	Trained	21	5.19	1.778
		Non-trained	20	4.80	1.735
	Post-test	Trained	21	6.19	1.167
		Non-trained	20	4.90	1.021

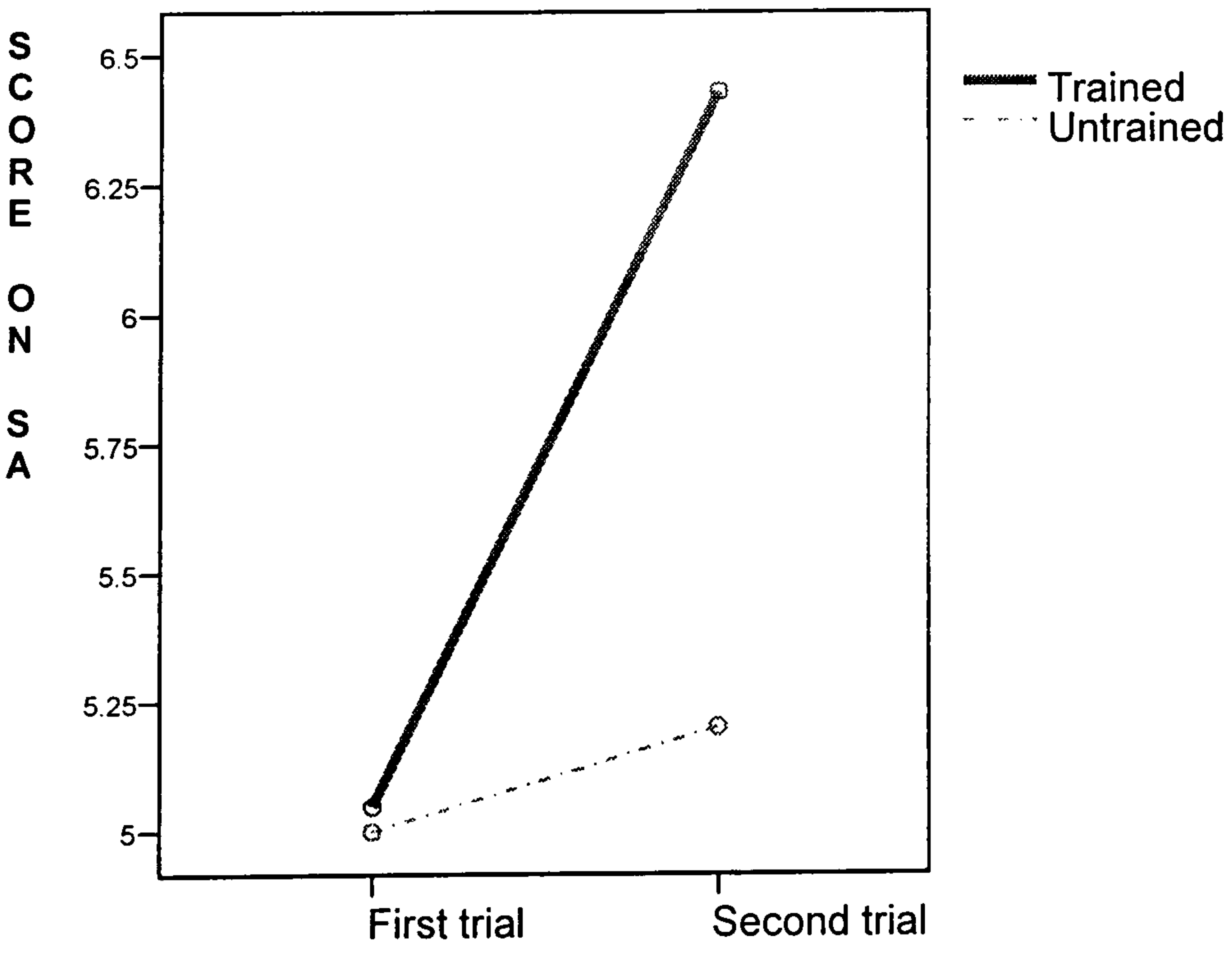


Figure 4.4 The interaction between the trained/untrained group and trial for situation assessment in the Creative problem-solving decision-making scenario

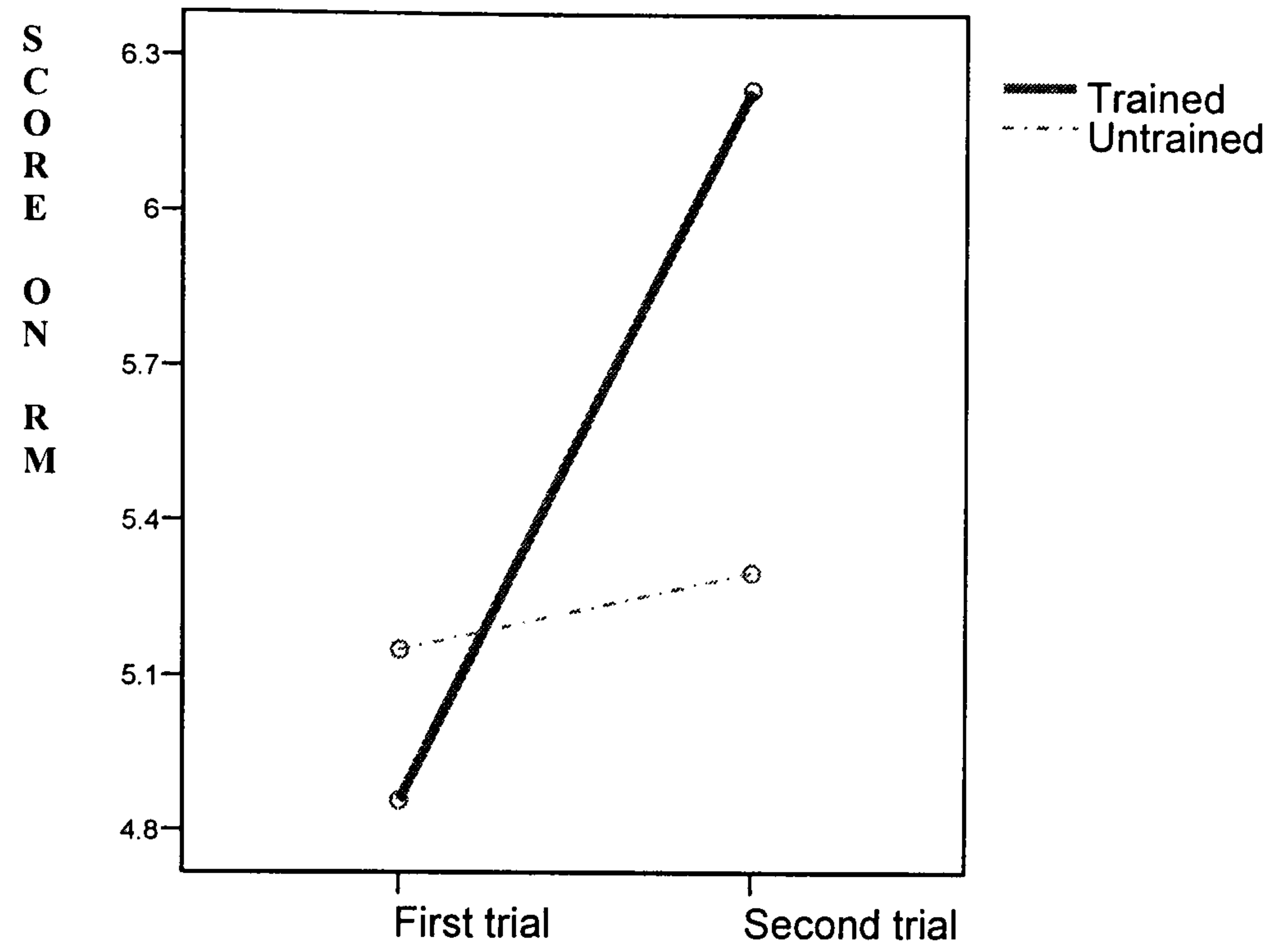


Figure 4.5 The interaction between the trained/untrained group and trial for risk management in the Creative problem-solving decision-making scenario

4.3.2 Pencil and Paper Based Assessments

4.3.2.1 Sample Characteristics

Each participant had their ADM performance assessed in a series of pencil and paper based evaluations in the six decision-making scenarios. In total 492 trials assessing pilots' ADM performance in the pencil and paper tests were undertaken, 252 scenarios in the experimental (trained) group and 240 scenarios in the control (untrained) group. There were two aspects of performance evaluated in each scenario, pilots' situation assessment and risk management.

4.3.2.2 Go/no go Decisions

There was no significant difference on the dimension of situation assessment before and after decision-making training ($F_{1,39}$=1.214; p=0.277). There was a result verging on significance between the trained and untrained group ($F_{1,39}$=3.277; p=0.078). The group that had received ADM training tended to outperform the group that had not received training (see table 4.5). There was also a significant interaction term between the trained/untrained group and before training trial/after training trial ($F_{1,39}$=4.355; p=0.043). The group that had received ADM training showed significantly greater gains in the second trial compared to the untrained group with decreased in performance (see figure 4.6).

There was no significant difference on the dimension of risk management before and after decision-making training ($F_{1,39}$=0.448; p=0.507). There was also no significant difference between the trained and untrained group ($F_{1,39}$=2.207; p=0.145). However, there was a result verging on significance for the interaction term between the trained/untrained group and trial ($F_{1,39}$=3.266; p=0.078). The group that had received ADM training showed greater gains on risk management in the second trial compared to the untrained group (see figure 4.7).

Table 4.5 Means and Standard Deviations in performance scores in the Go/no go decision-making scenario, broken down by main effect, on the both dimensions of situation awareness and risk management

Go/no go decisions		**Group**	**N**	**Mean**	**Standard deviation**
Situation assessment	Pre-test	Trained	21	5.38	1.203
		Untrained	20	5.25	1.743
	Post-test	Trained	21	6.19	0.981
		Untrained	20	5.00	1.654
Risk management	Pre-test	Trained	21	5.57	1.076
		Untrained	20	5.30	1.525
	Post-test	Trained	21	5.95	1.071
		Untrained	20	5.05	1.234

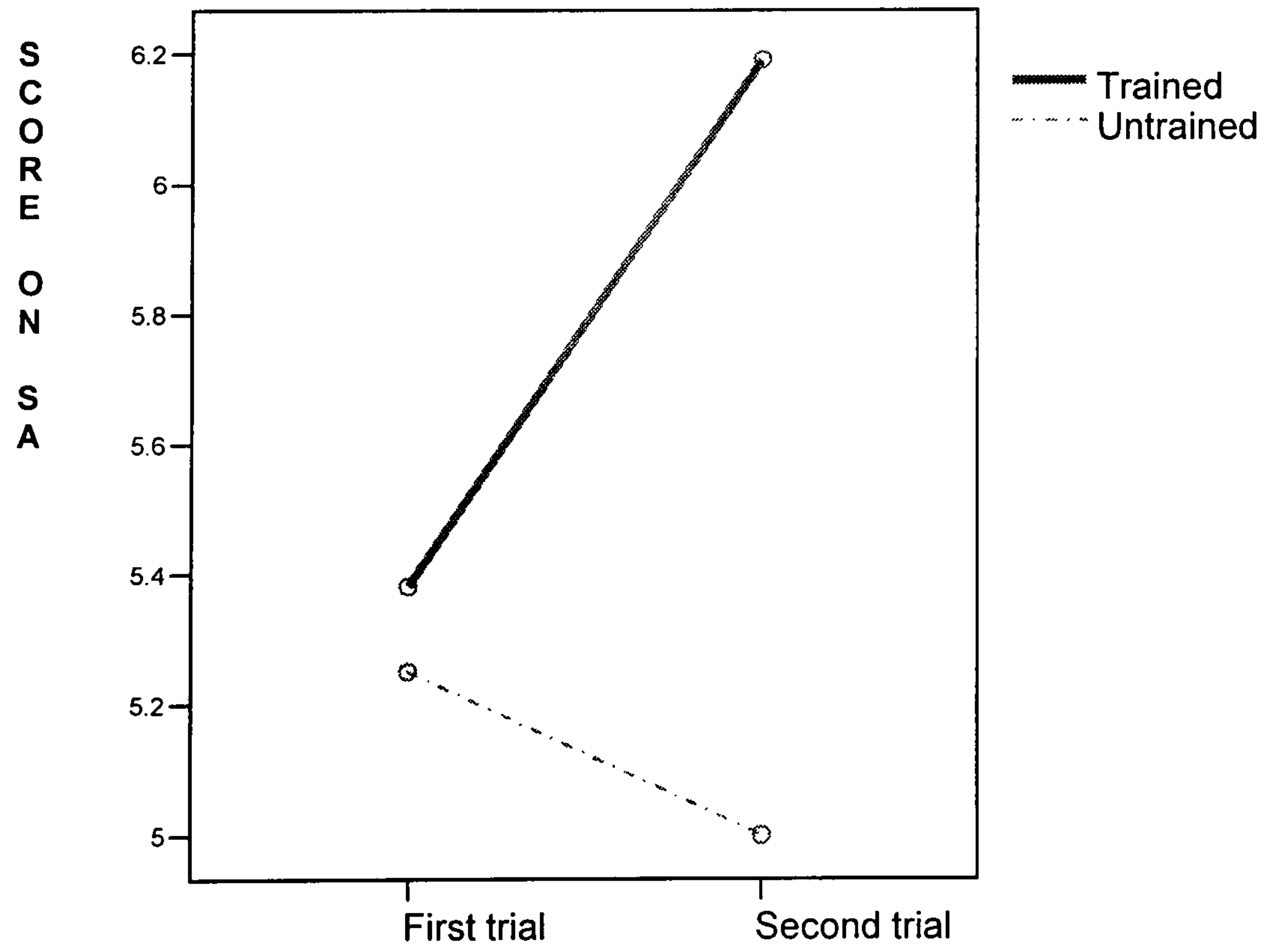


Figure 4.6 The interaction between the trained/untrained group and trial for situation assessment in the Go/no go decision-making scenario

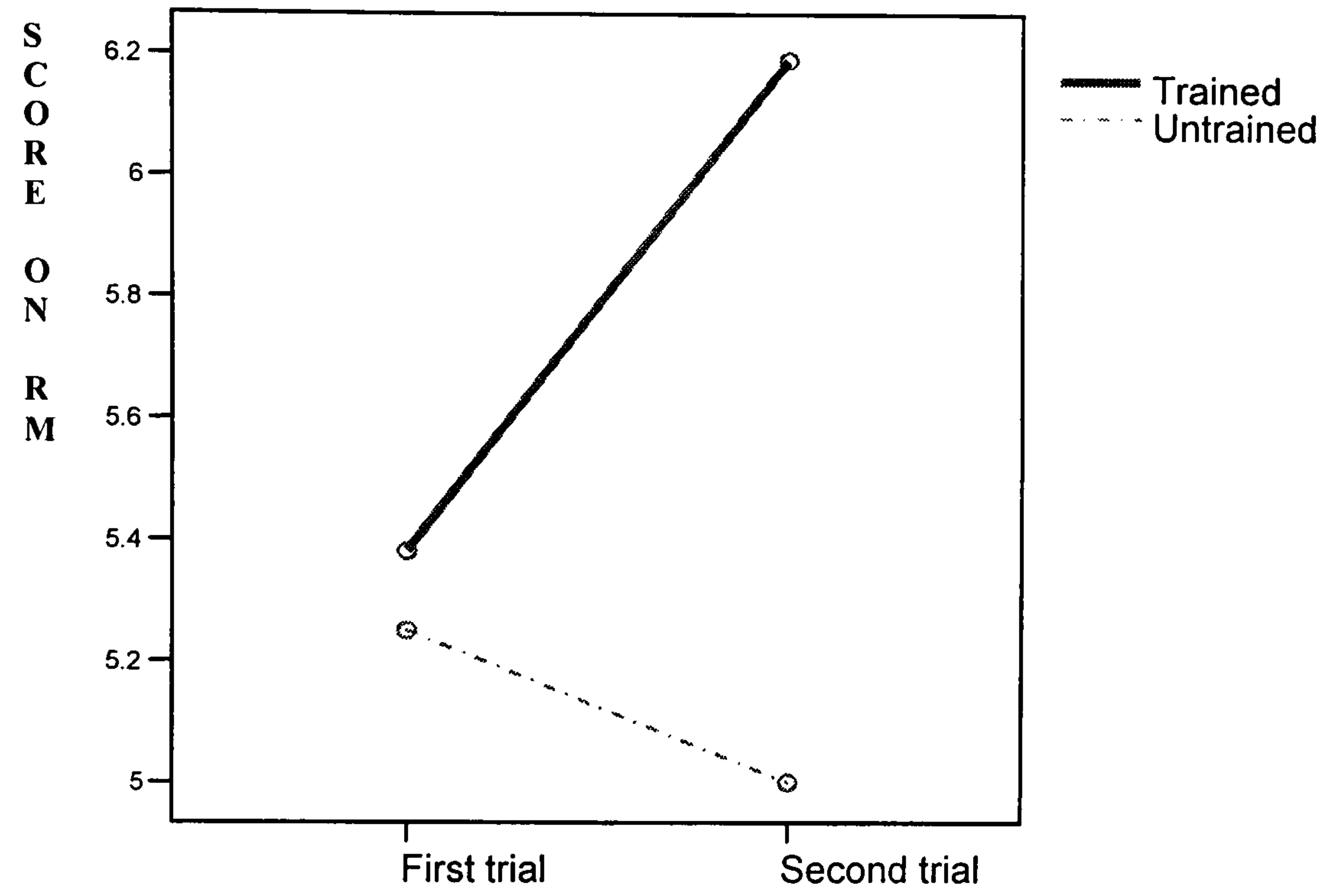


Figure 4.7 The interaction between the trained/untrained group and trial for risk management in the Go/no go decision-making scenario

4.3.2.3 Recognition-primed Decisions

There was no significant difference on the dimension of situation assessment before and after the decision-making training ($F_{1,39}$=0.927; p=0.342). There was also no significant difference between the trained and untrained group ($F_{1,39}$=1.337; p=0.225) (see table 4.6). However, there was a significant interaction term between the trained/untrained group and trial ($F_{1,39}$=9.555; p=0.004). The group that had received ADM training showed significantly greater gains in performance in the second trial compared to the untrained group (see figure 4.8).

There was no significant difference on the dimension of risk management before and after decision-making training ($F_{1,39}$=0.141; p=0.710). There was a result verging on a significant difference between the trained and untrained group ($F_{1,39}$=2.900; p=0.097). The group that had received ADM training tended to have better performance than the group that had not received training. There was also a result approaching statistical significance on the interaction term between the trained/untrained group and trial ($F_{1,39}$=3.266; p=0.078). The group that had received ADM training showed greater gains in performance in the second trial compared to the untrained group (see figure 4.9).

Table 4.6 Means and Standard Deviations in performance scores in the Recognition-Primed decisions scenario, broken down by main effect, on the both dimensions of situation awareness and risk management

Recognition-primed decisions		**Groups**	**N**	**Means**	**Standard deviations**
Situation assessment	Pre-test	Trained	21	5.43	1.121
		Untrained	20	5.55	1.234
	Post-test	Trained	21	6.10	0.944
		Untrained	20	5.20	1.436
Risk management	Pre-test	Trained	21	5.29	1.189
		Untrained	20	5.30	1.128
	Post-test	Trained	21	5.86	0.727
		Untrained	20	4.95	1.191

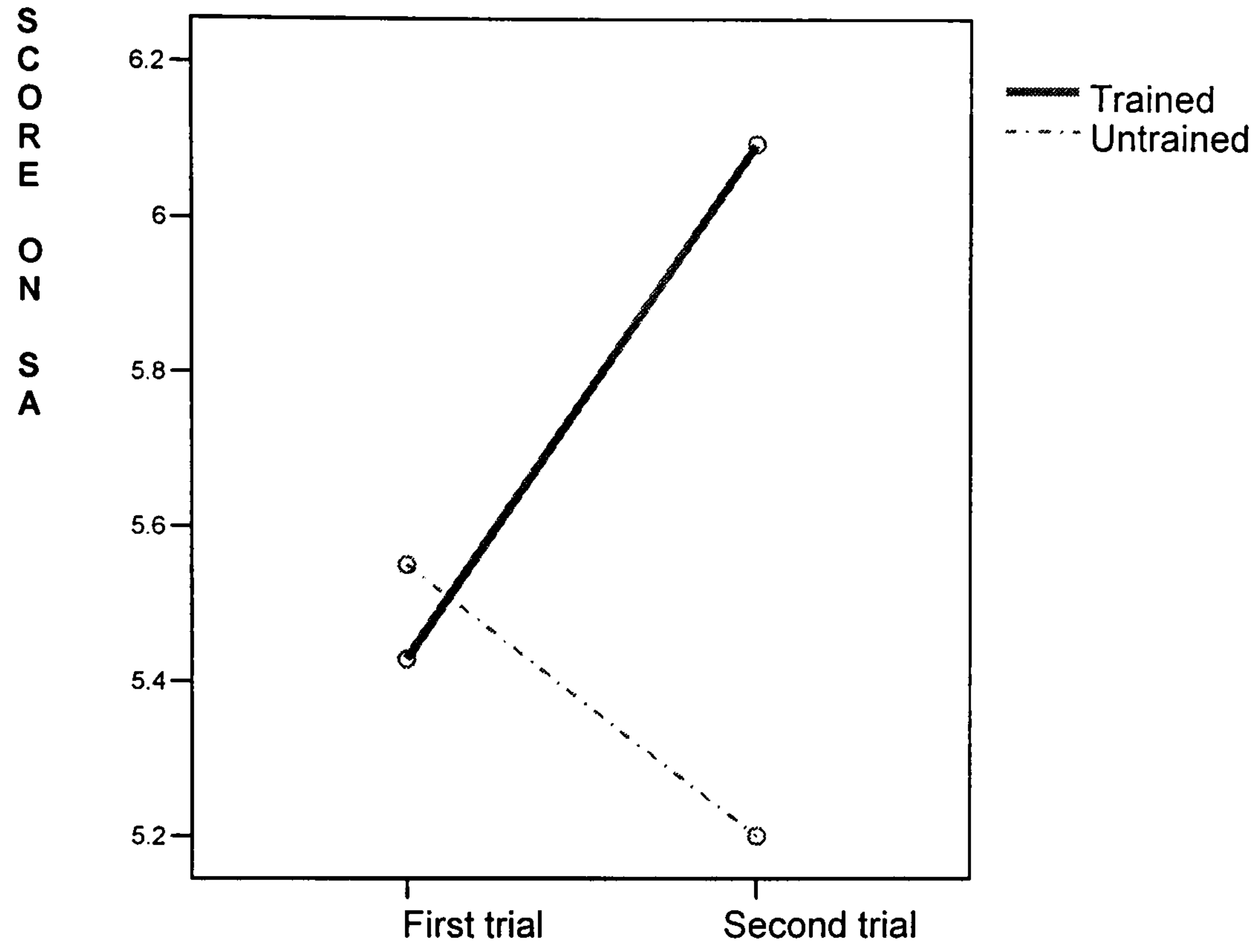


Figure 4.8 The interaction between the trained/untrained group and trial for situation assessment in the Recognition-Primed decision-making scenario

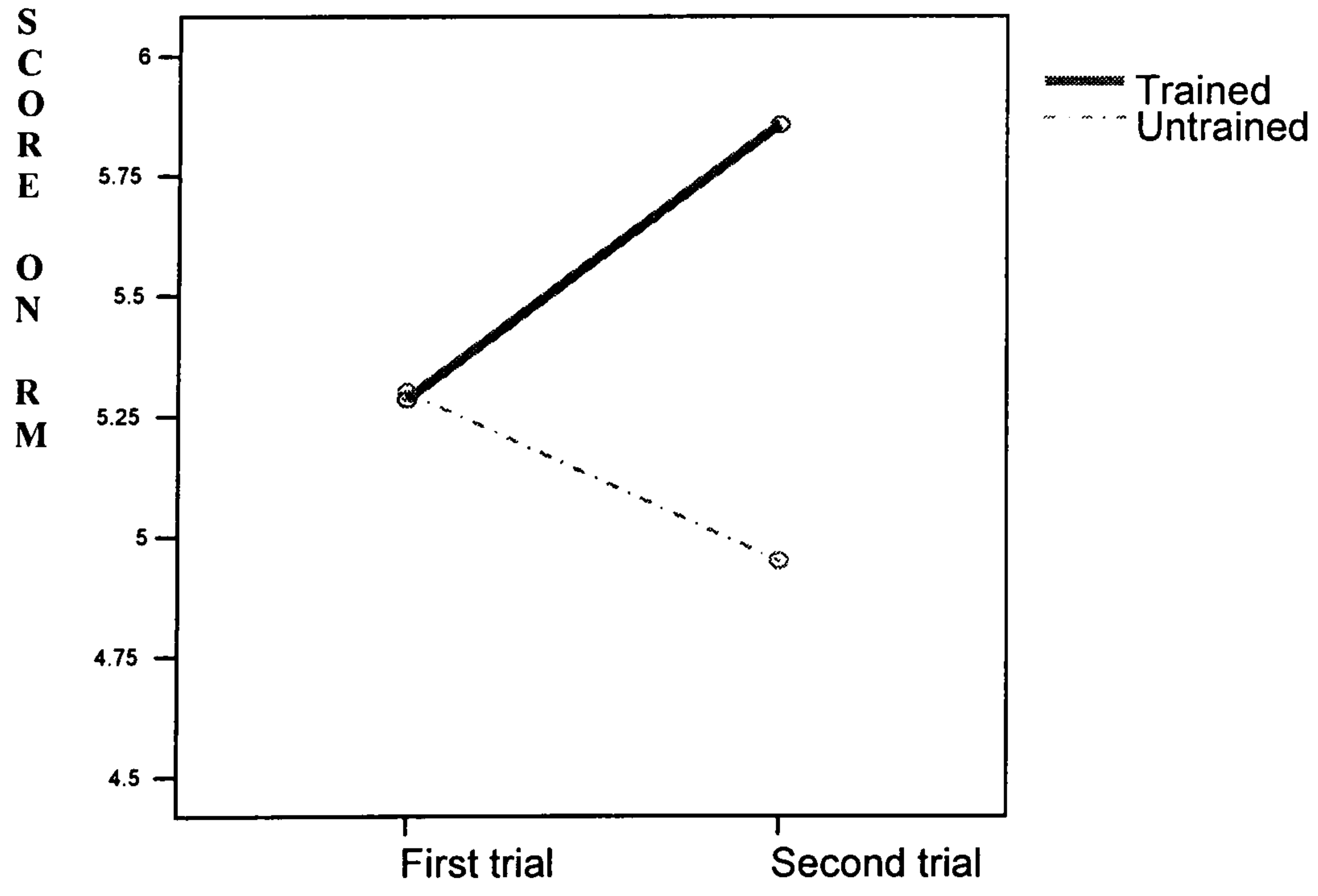


Figure 4.9 The interaction between the trained/untrained group and trial for risk management in the Recognition-Primed decision-making scenario

4.3.2.4 Response Selection Decisions

There was a result verging on a significant difference on the dimension of situation assessment before and after the decision-making training ($F_{1,39}$=3.246; p=0.079). It showed pilots' performance on the second trial to be better than on the first trial. There was also a result verging on significance between the trained and untrained group ($F_{1,39}$=3.277; p=0.078). The group that had received ADM training tended to outperform the group that had not received training (see table 4.7). There was no significant interaction between the trained/untrained group and trial ($F_{1,39}$=1.461; p=0.234).

There was no significant difference on the dimension of risk management before and after decision-making training ($F_{1,39}$=2.0641; p=0.112). There was a result verging on a significant difference between the trained and untrained group ($F_{1,39}$=4.022; p=0.052). The group that had received ADM training tended to have better performance than the group that had not received training. There was also a significant interaction term between the trained/untrained group and trial ($F_{1,39}$=5.591; p=0.023). The group that had received ADM training showed greater gains in performance in the second trial compared to the untrained group (see figure 4.10).

Table 4.7 Means and Standard Deviations in performance scores in the Response selection decision-making scenario, broken down by main effect, on the both dimensions of situation awareness and risk management

Response selection decisions		**Group**	**N**	**Mean**	**Standard deviation**
Situation assessment	Pre-test	Trained	21	5.14	1.459
		Untrained	20	4.75	1.552
	Post-test	Trained	21	5.90	0.995
		Untrained	20	4.90	1.774
Risk management	Pre-test	Trained	21	4.86	1.014
		Untrained	20	4.85	0.988
	Post-test	Trained	21	5.67	0.856
		Untrained	20	4.70	1.174

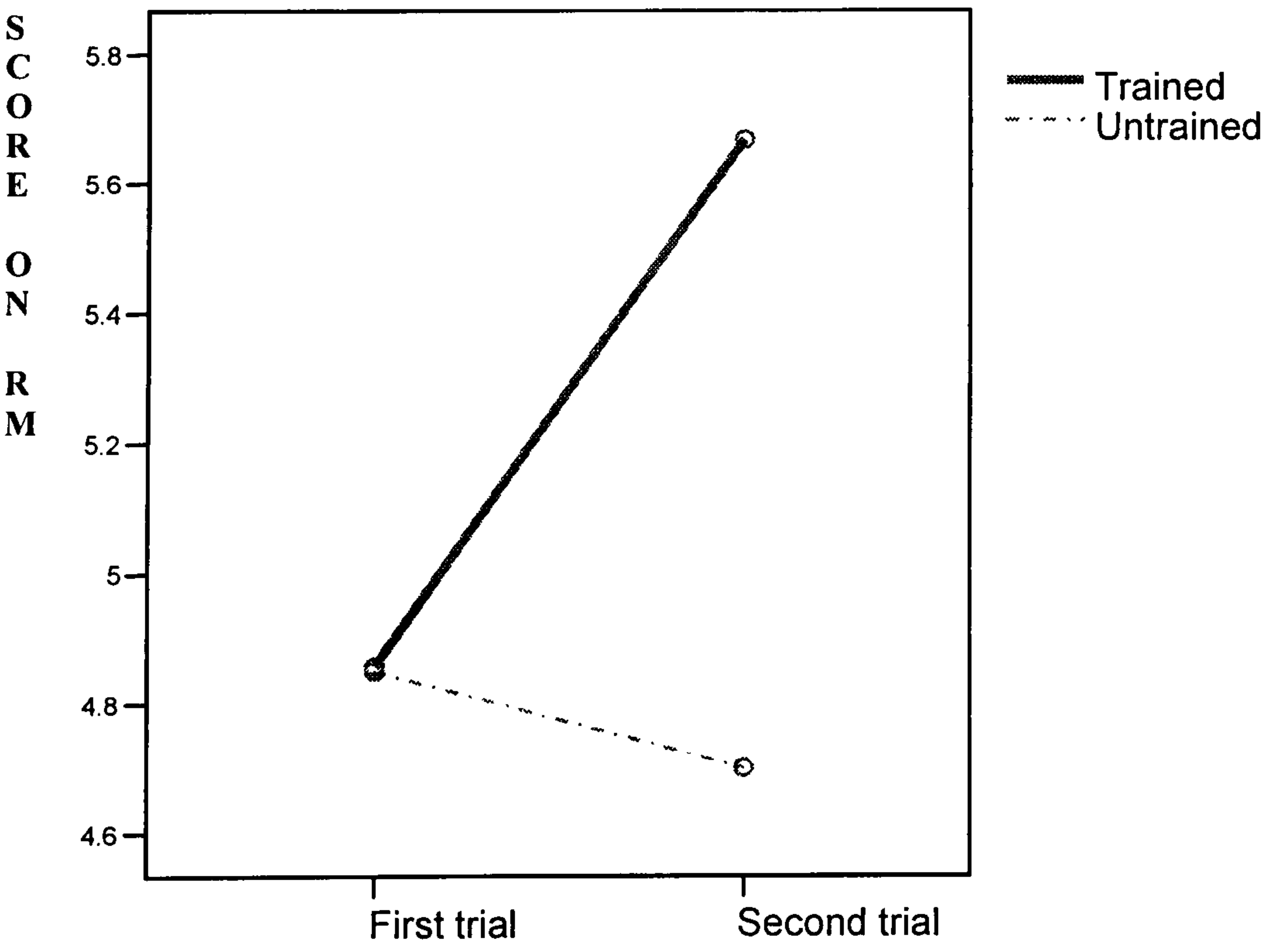


Figure 4.10 The interaction between the trained/untrained group and trial for risk management in the Response selection decision-making scenario

4.3.2.5 Resource Management Decisions

There was a significant difference on the dimension of situation assessment before and after decision-making training ($F_{1,39}$=4.914; p=0.033). It showed pilots' performance on situation assessment in the second trial to be better than on the first trial (table 4.8). There was no significant difference between the trained and untrained group ($F_{1,39}$=1.767; p=0.191). There was also no significant interaction term between the trained/untrained group and trial ($F_{1,39}$=1.238; p=0.273).

There was a result verging on statistical significance on the dimension of risk management before and after decision-making training ($F_{1,39}$=3.035; p=0.089). It indicated pilots' performance on risk management during the second trial to be better than the first trial. There was no significant difference between the trained and untrained group ($F_{1,39}$=0.052; p=0.820). Also, there was no significant interaction term between the trained/untrained group and trial ($F_{1,39}$=2.247; p=0.142).

Table 4.8 Means and Standard Deviations in performance scores in the Resource management decision-making scenario, broken down by main effect, on the both dimensions of situation awareness and risk management

Resource management decisions		**Group**	**N**	**Mean**	**Standard deviation**
Situation assessment	Pre-test	Trained	21	4.95	1.564
		Untrained	20	4.80	1.322
	Post-test	Trained	21	5.86	1.153
		Untrained	20	5.10	1.518
Risk management	Pre-test	Trained	21	4.71	1.189
		Untrained	20	4.95	0.999
	Post-test	Trained	21	5.38	1.071
		Untrained	20	5.00	1.522

4.3.2.6 Non-Diagnostic Procedural Decisions

There was no significant difference on the dimension of situation assessment before and after decision-making training ($F_{1,39}$=1.007; p=0.322). There was a result verging on significance between the trained and untrained group ($F_{1,39}$=3.593; p=0.065). The group that had received ADM training tended to outperform the group that had not received training (see table 4.9). There was also a significant interaction term between the trained/untrained group and pre-test/post-test ($F_{1,39}$=19.540; p=0.000). The group that had received ADM training showed significantly greater gains in performance in the second trial compared to the untrained group (see figure 4.11).

There was no significant difference on the dimension of risk management before and after decision-making training ($F_{1,39}$=0.067; p=0.797). There was no significant difference between the trained and untrained group ($F_{1,39}$=1.887; p=0.177). There was a result verging on significance for the interaction term between the trained/untrained group and trial ($F_{1,39}$=3.266; p=0.078). The group that had received ADM training showed greater gains in performance in the second trial compared to the untrained group (see figure 4.12).

Table 4.9 Means and Standard Deviations in performance scores in the Non-diagnostic procedural decision-making scenario, broken down by main effect, on the both dimensions of situation awareness and risk management

Non-diagnostic procedural decisions		**Groups**	**N**	**Means**	**Standard deviations**
Situation assessment	Pre-test	Trained	21	5.00	1.304
		Untrained	20	5.30	1.218
	Post-test	Trained	21	6.19	1.123
		Untrained	20	4.55	1.638
Risk management	Pre-test	Trained	21	4.95	1.161
		Untrained	20	5.25	1.070
	Post-test	Trained	21	5.71	0.956
		Untrained	20	4.60	1.465

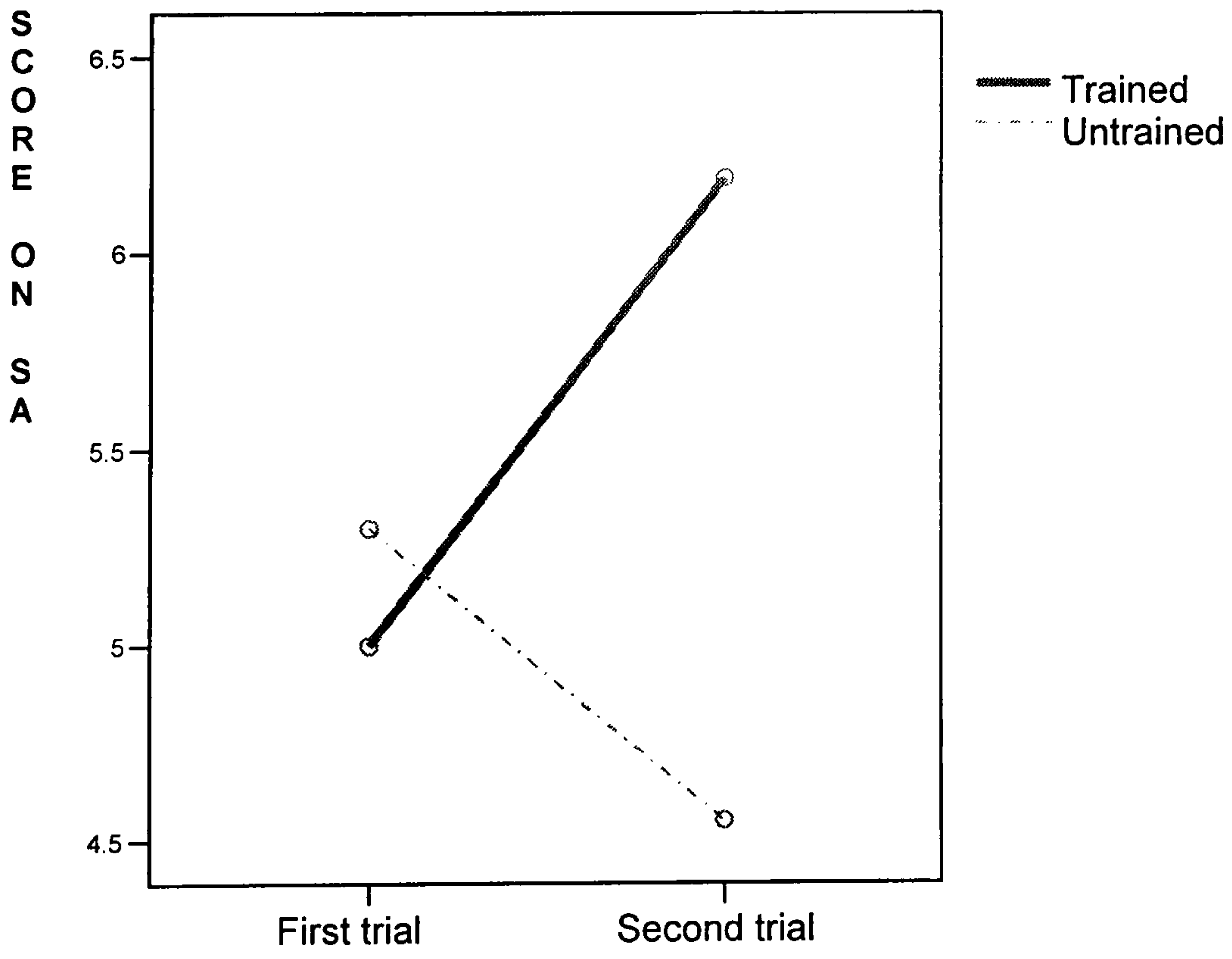


Figure 4.11 The interaction between the trained/untrained group and trial for situation assessment in the Non-diagnostic procedural decision-making scenario

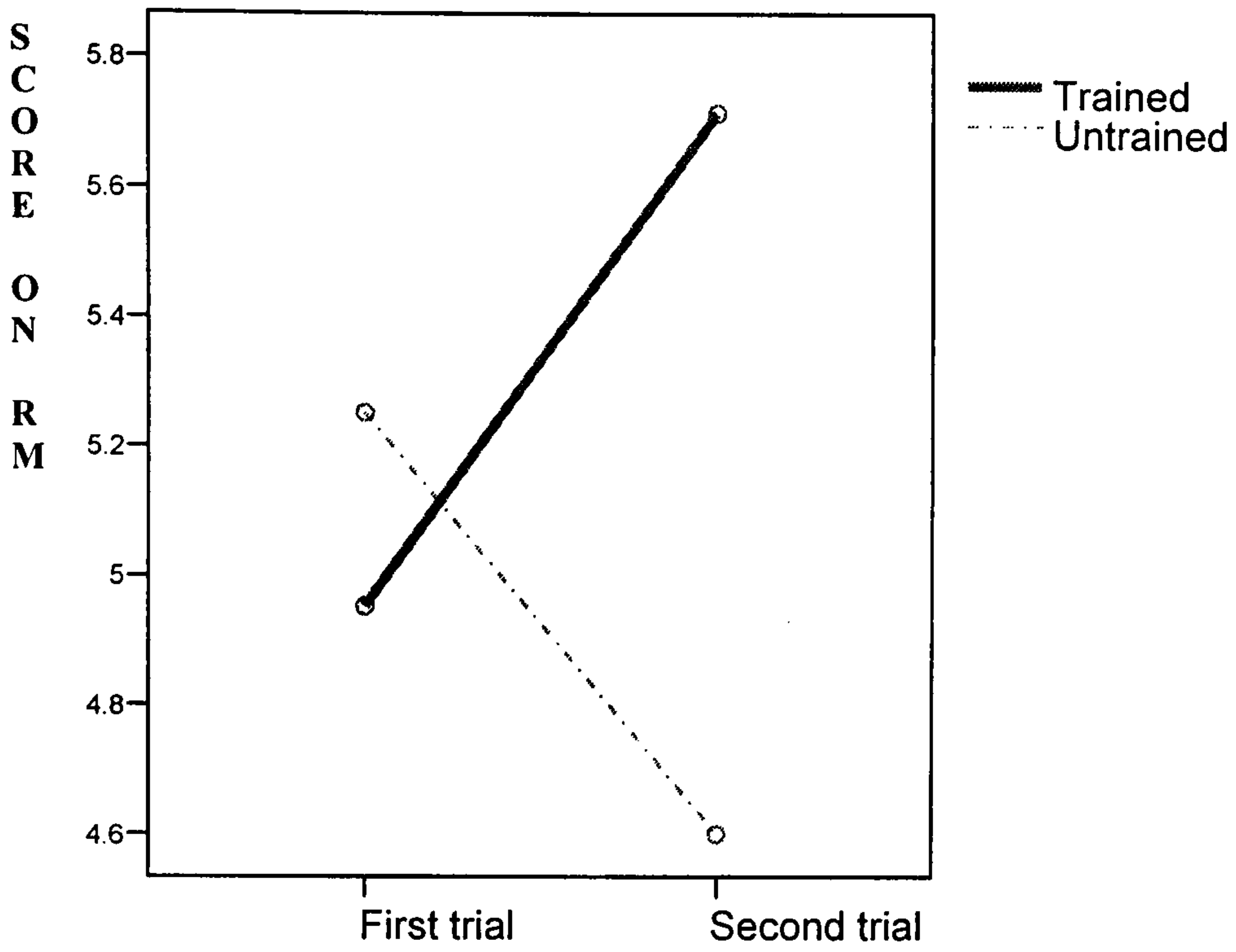


Figure 4.12 The interaction between the trained/untrained group and trial for risk management in the Non-diagnostic procedural decision-making scenario

4.3.2.7 Creative problem-solving

There was a significant difference on the dimension of situation assessment before and after decision-making training ($F_{1,39}$=10.320; p=0.003). It showed the pilots' performance in situation assessment in the second trial was better than the first trial (see table 4.10). There was no significant difference between the trained and untrained group ($F_{1,39}$=0.187; p=0.668). There was also no significant interaction term between the trained/untrained group and trial ($F_{1,39}$=2.393; p=0.130).

There was a significant difference on the dimension of risk management before and after decision-making training ($F_{1,39}$=5.885; p=0.020). It indicated pilots' performance on risk management during the second trial was better than in the first trial. There was no significant difference between the trained and untrained group ($F_{1,39}$=0.162; p=0.690). Also, there was no significant interaction term between the trained/untrained group and trial ($F_{1,39}$=2.509; p=0.121).

Table 4.10 Means and Standard Deviations in performance scores in the Creative problem-solving scenario, broken down by main effect, on the both dimensions of situation awareness and risk management

Creative problem-solving		**Groups**	**N**	**Means**	**Standard deviations**
Situation assessment	Pre-test	Trained	21	4.71	1.347
		Untrained	20	4.90	1.483
	Post-test	Trained	21	5.71	1.007
		Untrained	20	5.25	1.020
Risk management	Pre-test	Trained	21	4.71	1.347
		Untrained	20	4.95	1.761
	Post-test	Trained	21	5.67	0.966
		Untrained	20	5.15	1.226

4.4 Discussion

The decision to abort a take-off requires a different decision process from losing a formation leader in clouds or choosing an alternative airfield for landing with bingo fuel. The nature of the cognitive processes involved in a decision depends on the requirements of the tasks and the surrounding environment. Therefore, no single method can improve decision-making performance in all situations (Orasanu, 1993). The ADM training program included SHOR, the quickest ADM mnemonic to apply, and DESIDE, the most comprehensive mnemonic. The ADM training program also addressed the use of different decision-making theories across six basic types of decision-making scenario to trigger pilots' awareness regarding to the role of ADM in tactical tasks a topic which had never been taught in their basic flight training, advanced training or conversion training. This research used pencil and paper trials for assessing pilot's process performance in six basic types of decision-making scenario. In three simulator trials, which used only recognition-primed decisions, non-diagnostic procedural decisions, and creative problem solving scenarios, the products of decision-making were evaluated. The main purpose of this research was to evaluate the efficiency of the ADM training program.

4.4.1 The Impact of the ADM Training Intervention on Go/No Go Decisions

The pre-test and post-test scenarios were quite similar in go/no go decision scenarios. In both instances other aircraft had a problem during a formation take-off run. Pilots had to make a decision under time pressure with high risk. As the patterns were recognized and responses were pre-set, the cognitive work of pilots was essentially perceptual and interpretive (Orasanu, 1993). It is likely pilots would follow the pre-set rules and SOPs for making a rapid decision. According to the findings from the pencil and paper trials, the trained group made significant improvements on both the dimensions of situation assessment and risk management compared to the untrained group (table 4.5). Both dimensions also had significant interaction effects. The ADM training intervention had a positive impact on the dimensions of situation assessment and risk management.

4.4.2 The Impact of the ADM Training Intervention on Recognition-primed Decisions

The aircraft's engine failed as a result of FOD (Foreign Objects Damage) on take-off in both the pre-test and post-test scenarios in recognition-primed decision-making situations. Pilots have to make a quick decision to deal with urgent situations. The findings from the pencil and paper trials confirm that as soon as pilots assess these situations properly, the response strategies are retrieved on the basis of their past success experience, as proposed by Klein (1993a). The findings from the simulator trials provided further evidence that this ADM training program improved pilots' situation assessment and risk management. There were significant differences between the pre-test and post-test results and the pencil and paper trials also showed significant interaction effects on situation assessment and risk management.

However on the dimension of 'response time' it took longer for trained group in the post-test on simulator trials (table 4.2). This is a reasonable result, as pilots in the trained group undertook a more comprehensive consideration when assessing the situation and when making a plan to manage the impending risks. As a result the processes of situation assessment and risk management will consume more time than when using an automatic response with no considered strategy. As Klein (1993) suggested, the recognition-primed decision model explaining how people make decisions focuses on two processes, situation assessment (to generate a plausible course of action) and mental simulation (to evaluate that course of action for risk management). If a pilot recognizes there is sufficient time to make a considered decision, he will evaluate the dominant response option by imagining it and conducting a mental simulation to see if it will work. If there is not adequate time, the pilot will tend to implement the course of action that experience has determined as the most likely to be successful. Although the situation was urgent and needed a fast response, pilots showed that appropriate situation assessment and effective risks management before making a decision was more favorable than rushed reactions.

4.4.3 The Impact of the ADM Training Intervention on Response Selection Decisions

The wingman has to make a decision to choose a response to deal with an impending hazard in both the pre-test and post-test scenarios in the response selection decision-making scenarios. Although these are not urgent situations, pilots may perceive the potential risk in front of them to be very high and choose an inappropriate response. The findings from the pencil and paper trials showed the ADM training program to have a positive effect in improving pilots' situation assessment and risk management (table 4.7). Although the interaction effect was not significant on the dimension of situation assessment, the main effects of trained/untrained group and pre-test/post-test were verging on significant. The trained group had greater gains in ADM performance than the untrained group in the post-test on dimensions of situation assessment and risk management.

4.4.4 The Impact of the ADM Training Intervention on Resource Management Decisions

The pilots were practicing Air Combat Maneuvers with the potential for a mid-air collision in the pre-test and post-test scenarios in the resource management decision situations. The cognitive work that must be done in this type of decision includes establishing priorities amongst the various tasks, assessing available resources, estimating the available time, and developing an action plan (Orasanu, 1993). According to the results of the pencil and paper trials, the ADM training program had a positive effect in improving pilots' situation assessment and risk management after the training intervention (table 4.8). Although the main effect of trained/untrained group and the interaction effects were not significant, the main effect of before/after training was significant for situation assessment and verging on being significant for risk management. Perhaps the most critical issues for resource management decisions are setting the priorities for response. For example, certain actions must be done within a few seconds to avoid a mid-air crash, such as descending or climbing or changing direction with a call-out to alert the other wingman. Generally, pilots had better performance with regard to situation assessment and risk management after the training intervention.

4.4.5 The Impact of the ADM Training Intervention on Non-diagnostic Procedural Decisions

Pilots had to evaluate the strengths and weakness of using alternative airfields in deteriorating weather in a 'bingo fuel' situation in both the pre-test and post-test scenarios in the non-diagnostic procedural decision situations. According to the results of the simulator and pencil and paper trials, the ADM training program significantly improved pilots' situation assessment and risk management in this ill-defined situation (tables 4.3 & table 4.9). The interaction effects were significant on both the dimensions of situation assessment and risk management. The scores in the post-test were significantly higher than the scores in the pre-test for the trained group.

The dimension of 'response time' had a significant main effect before/after the training intervention. The trained group took more time to form a response strategy in the post-test scenario (table 4.3). This is the least clearly defined type of decision situation as it involves a pattern of cues that fall into a category which has no prescribed response. Many different types of ambiguous cue may signal danger. Training for these cases involves mainly situation assessment and risk management (Orasanu, 1993). In this type of scenario, pilots had more time to assess the situation and project the situation into the near future for managing the potential risks. The pilots in the trained group gained significantly higher scores on situation assessment and risk management in the post-test than the untrained group. The more extensive considerations using the mnemonics resulted in a longer time to form a decision. To minimize the response time but while maintenance the increased quality of situation assessment and risk management, practicing non-diagnostic procedural decisions in a simulator might help.

4.4.6 The Impact of the ADM Training Intervention on Creative Problem-solving

Pilots had to resolve the problems presented by generator failures and a landing gear abnormal condition in the pre-test and post-test scenarios. The results of the simulator trials showed the ADM training program to significantly improve performance on the dimensions of situation assessment and risk management. The interaction effects for both dimensions were also significant. The cognitive processes for this type of decision task are the most complex, because they involve both diagnosis to determine the nature of the situation and response generation for dealing with an ambiguous problem. Once the nature of the problem has been determined, there may be no recommendations in the SOPs/manuals. Pilots receiving the ADM training program showed better situation assessment and risk management for determining what their problems were and planning their actions to solve the problems (table 4.4). The pencil and paper trials also showed the ADM training program to have a positive effect on pilots' performance on situation assessment and risk management (table 4.10). However, the evidence was not as strong in this case as simulator trials (table 4.11).

The dimension of 'response time' had an effect verging on significance on the main effect of before/after training intervention in simulator trials. The trained group took more time to form the response strategies in the post-test scenario (table 4.4). It was evident that pilots did apply the ADM mnemonics for analyzing the situations and evaluating the risks when forming response strategies. However, pilots need further time to practice the decision-making strategies from the ADM training. As a result the pilots who received ADM training took longer as they spent more time undertaking the cognitive processes necessary for safe action.

4.4.7 The Differences between Simulator Trials and Pencil and Paper Trials

There were three significant interaction effects on both the situation assessment and risk management dimensions on the pencil and paper trials. These were go/no go decisions, recognition-primed decisions, and non-diagnostic procedural decisions. For response selection decisions, only risk management had a significant interaction effect. Resource management and creative problem-solving decisions had no significant interaction effects on situation assessment and risk management, however, both scenarios had significant main effects on situation assessment and risk management before/after training. After the training intervention pilots had better decision-making performance than before training based on the result of the paper-pencil trials. On the other hand, the simulator trials had significant interaction effects on non-diagnostic procedural and creative problem-solving decisions on both the situation assessment and risk management variables. Recognition-primed decisions had a significant interaction effect on response time. Both non-diagnostic procedural and creative problem-solving decisions had significant main effects on situation assessment, risk management and response time before/after training. This suggests that the ADM training program improved pilots' decision-making performance across all six basic types of decision-making (table 4.11).

Table 4.11 The summary of main effects of before/after training and trained/untrained groups and interaction effects on the simulator trials and paper-pencil trials on situation assessment, risk management, and response time across six basic types of decision-making scenarios

Six basic types of decisions	**Dimensions of evaluation**	**Main effect of before/after training**		**Main effect of trained/untrained**		**Interaction effects**	
		S trials	**P-P trials**	**S trials**	**P-P trials**	**S trials**	**P-P trials**
Go/no go decisions	SA	na		na	👍	na	√
	RM	na		na		na	👍
Recognition-primed decisions	SA	👍		√			√
	RM	√		√	👍		👍
	RT		na		na	👍	na
Response selection decisions	SA	na	👍	na	👍	na	
	RM	na		na	👍	na	√
Resource management decisions	SA	na	√	na		na	
	RM	na	👍	na		na	
Non-diagnostic procedural decisions	SA	√			👍	√	√
	RM	√		👍		√	👍
	RT	√	na		na		na
Creative problem-solving	SA	√	√	👍		👍	
	RM	√	√			√	
	RT	👍	na	√	na		na

Notes: 1. **S** means simulator trial.

2. **P-P** means paper-pencil trials.

3. na means not applicable.

4. √ means significant (.00-.05).

5. 👍 means verging on significance (.05- .099).

Typically, training evaluation involves a series of levels, from the assessment of pilots' reactions to training, through the measurement of individual changes in knowledge and behavior, to the measurement of organizational change (Kirkpatrick, 1976). Simulator trials offer the option of being able to provide pilots with many practice problems, designed to build up their recognition of patterns. They can consistently be adapted to the pilot in terms of difficulty level and in terms of evaluating pilots' skills/knowledge and behavior. Pilots can perform tactical tasks in the context of a simulated environment and missions and pilots can be evaluated in terms of their decision-making performance by an instructor. Pencil and paper trials have limitations for evaluating pilots' behavior.

The pencil and paper trials can analyze the cognitive processes of a pilot, for example what aspects of situation assessment and risk management were conducted during a pilots' mental simulation. However, this research approach can't assess the real-time performance of pilots' in-flight decision-making. It also has a lack of psychological time-pressure. The key cues for pilots' decision-making are time and risk (Orasanu & Fisher, 1997). In emergency situations, uncertainty may outweigh time pressure as the key stressor bearing on the decision-making strategy (Lynne, Flin & Skriver, 1997). Based only upon the pencil and paper trials it is difficult to conclude whether it was the cognitive processes of pilots for conducting situation assessment and risk management that caused longer response time, as the pencil and paper trials were not suitable for assessing 'response time'. On the other hand, simulator trials can assess the products of the ADM performance of pilots' including the situation assessment, risk management, and response time in real-time setting, however, they had limitations for analyzing the cognitive processes of pilots.

4.4.8 Trade-off Effect in Decision-making Process

All in-flight decisions are made under uncertainty. Evaluating a decision as good or not must depend on the stakes and the probability of successful performance, not just on the outcome. It is important to evaluate both the 'products' and 'process' of ADM training efficacy. Overall, results from both the simulator-based trials (which assessed the *product* of the ADM training programme) and the pencil-and-paper tests (which assessed the *process* that the trainees applied) showed gains being made in both Situation Assessment and Risk Management skills which were attributable to the decision-making training course. The ADM training program improved pilots' situation assessment and risk management. However, the assessed response time of the trained group was longer than the untrained group in all three simulator trials, although only in the recognition-primed decision scenario was there a significant interaction effect. However, the non-diagnostic procedural decision-making scenario had a significant main effect of before/after training and the creative problem-solving scenario had a main effect that was significant on before/after training and on trained/untrained group. All these results indicate that response times did increase after pilots received ADM training. There were two possible explanations; firstly, as pilots were not familiar with the ADM mnemonics, they spent more time applying these steps. After they have had more opportunity to practice these ADM mnemonics, their response times may be quicker. Secondly, simply thinking more takes more time. However, the results of evaluating both dimensions of situation assessment and risk management suggested the quality of the decisions made was superior after training.

4.5 Summary

The nature of a decision depends on the requirements of the tasks and the conditions of the surrounding environment. If the situation confronted is not coincident with established SOPs or previous experience, pilots must conduct their analysis of the problem and select a solution from the available options assessed by mental simulation. However, it takes time to conduct a mental simulation to form a course of action for dealing with a problem. This research has proved that an ADM training program does improve pilots' in-flight decision-making performance. However, when improvements in pilots' situation assessment and risk management were obtained, they tended to be traded-off against response time. As Klein (1993) advised, experience affects decision making by improving the ease and accuracy of situation assessment, and by enabling the decision maker to construct and use a mental simulation. A simulator provides many alternative options for practice to build up experience and recognition of patterns.

The longer-term effectiveness of such ADM training courses needs evaluation to see if it translates into improved decision-making behavior during day-to-day operations which should ultimately also result in a reduction in the accident rate attributable to poor decision-making. There is also a need to investigate if additional practice in the application of the ADM mnemonic methods in a flight simulator increases the speed of decision-making. Nevertheless, it is suggested that a simple, short, cost-effective training program in the appropriate use of ADM mnemonic methods may ultimately produce significant gains in flight safety. Such a course may easily be integrated into current CRM or simulator-based training programs.

CHAPTER V

Summary and Overview

5.1 Overview

As Orasanu (1993) pointed out, all types of decisions have at least three elements in common; choice among options, situation assessment, and risk assessment. Beyond these three common elements, decision problems in the cockpit also differ in their underlying structure, time parameters, and information characteristics. They require different kinds of mental work. Pilots have little control over the uncertain situations which may confront them when flying an aircraft. Therefore, it is important to identify their ADM training needs and equip pilots with relevant strategies for making appropriate decisions in dynamic tactical environments.

The Interservice Procedures for Instructional System Development (IPISD) adopts what is known as a systems perspective, where training development is viewed as a system that attempts to achieve a particular goal (Branson et al., 1975). The aim was to provide a context-free framework for the development good training programs. The IPISD model divided the development of training into five main phases: analyze, design, develop, implement and control. These phases are in a logical order, phase-1 identifying training needs, so that the content of training can be specified; phase-2 specifies training objectives and map out the overall structure of training program; phase-3 develops the training content into effective learning materials and delivers the instruction; phase-4 implements the training program; and phase-5 evaluates the training intervention. This chapter summarizes the three studies undertaken. Study-1 was the identification of ADM training needs using HFACS. It is corresponds to phase one (analyze) of IPISD, as this study was concerned with analyzing the training requirements. Study-2 was the assessment of the suitability of ADM training mnemonics. It was related to phases two and three (design and development) of IPISD, as this study was involved in determining the structure of ADM training and developing the content of ADM training program. Study-3 was concerned with evaluating the effectiveness of the ADM training program for military pilots. It corresponded to phases four and five (implement and control) of the IPISD model in conducting the instruction and evaluation of ADM training program.

5.2 Analysis of ADM Training Needs Using HFACS

The HFACS is a framework originally developed by Wiegmann & Shappell (1997) for underlying U.S. military aviation as a tool for investigating and analyzing the human factors accidents. This framework analyses accidents at four levels with 18 causal categories of human errors based on Reason's latent and active failures model, with each higher level affecting the next downward level. This research found that there were significant associations among categories in the HFACS framework from level-4 ‘organizational influences’ to ‘decision errors’ in level-1. The category of ‘inadequate supervision” was found to be the critical factor in the HFACS framework, because it was affected by ‘resource management’, ‘organizational climate’, and ‘organizational process’ and it in turn affected 'adverse mental states', 'physical/mental limitations', 'crew resource management', and 'personal readiness', all of which had significant associations with ‘decision errors’. The results show ‘decision errors’ had involved in 223 (42.6%) of accidents as a significant contributory factor in aviation mishaps.

Concerning the nature of the military mission, pilots have to perform a wide range of tasks. Pilots must learn to make decisions related to mission performance whilst operating complex systems of the aircraft which they are flying. There was a need identified for aeronautical decision-making to be trained directly and incorporated into the tactical environment. For developing ADM training programs to fit specific military missions and aircraft, a matrix can be formed by three dimensions consisting of missions, types of aircraft, and contents of HFACS categories affecting decision-making. ADM training programs should focus not only on pilot's decision-making, but also upon awareness of military tasks, type of aircraft and type of decision all of which may affect the decision-making strategy to be employed.

5.3 Suitability of ADM Training Mnemonics in Tactical Environments

This study was to develop the contents of ADM training program by evaluating the efficiency of five ADM mnemonic methods in six different tactical situations. By specifying different tactical situations military pilots may confronted, the purpose was to find the best ADM mnemonic across different decision-making scenarios to form the foundation of training program. SHOR was developed for use in U.S. Air Force tactical command and control scenarios, where decisions were likely to be made under high pressure and within severe time (Wohl, 1981). The contents of SHOR matched the requirements of the decision-making scenarios requiring urgent decisions. SHOR is able to promote quick responses in a time-limited situation and it also corresponds to the basic principles of briefing during tactical training.

Murray (1997) suggested that the DESIDE mnemonic-based decision making method was a practical approach for assisting pilots when making decisions in such situations. The respondents in this study also indicated that when they had time to consider their options more fully they regarded the DESIDE mnemonic-based ADM method as being the most suitable. The qualitative data also showed that this method had suitable characteristics for dealing with non-urgent situations. It was rated highly for situation assessment, risk management, and applicability; it was thought to be comprehensive and thorough; clear about how to identify the safest actions; and it also had a logical order and was easy to remember. However, it did require much more time to perform this analysis and produce a response. Instructor pilots advised that practicing DESIDE in the simulator was extremely important before attempting to apply it in a real-time situation.

The two ADM mnemonic methods, SHOR (Wohl, 1981) and DESIDE (Murray, 1997), that had been previously been assessed by instructor and cadet pilots as being the most applicable and having the potential to significantly improve the quality of military pilots' decision-making in study two (Li & Harris, 2005) formed the basis of the ADM training program. The training program commenced with an introduction to ADM theories; followed by a description of the content and method of application of the SHOR and DESIDE ADM mnemonic-based methods. Following this, participants practiced in the classroom the application of SHOR and DESIDE in flight situations exemplifying the six basic types of decision making scenario described by Orasanu (1993). Finally, the application of ADM in military aviation was described and the participants undertaking the training were de-briefed. The results showed that pilots would apply SHOR for the scenarios which they thought were urgent situations, where quick responses were needed; and DESIDE for the scenarios which they thought were not urgent situations, where comprehensive considerations were preferable to deal with the problems. The qualitative differences in the ratings of the suitability of ADM mnemonics between experts and novices were probably a result of hazard perception. To optimize the effectiveness of decision-making training, it was suggested that it was necessary to deliver instruction using both the SHOR and DESIDE ADM mnemonic methods and also to provide advice concerning which approach was most suitable in which situations in the tactical environment. It was also identified as being necessary to instruct pilots both with regard to the operation of the individual techniques and to recognize which technique is most appropriate to apply in a given circumstance.

The principal limitation of the second study though was that it only elicited instructor and cadet pilots' opinions about the efficacy of these decision-making techniques. Further research was required to be undertaken to produce empirical data using a full-flight simulator to establish if training in the use of ADM mnemonic-based methods such as SHOR and DESIDE could improve pilot decision-making. These data were necessary verify the opinions of the instructor pilots elicited in this study. The third study was required to justify the effectiveness of ADM training interventions based on SHOR and DESIDE mnemonics methods in the six basic decision-making scenarios in the real time tactical environments.

5.4 The Evaluation of the ADM Training Program

The ADM training program included SHOR, the quickest ADM mnemonic, and DESIDE, the most comprehensive mnemonic. The main purpose of this research was to evaluate the efficiency of ADM training program for military pilots using a flight simulator and pencil and paper trials. The pencil and paper trials analyzed the cognitive 'processes' of pilots, for example what aspects of situation assessment and risk management were conducted by pilots' mental simulation. However, this research approach could not assess the real-time performance of pilots' in-flight decision-making. It also has a lack of psychological time-pressure. Pencil and paper trials were also not suitable for evaluating the dimension of 'response time' of pilots' decision-making performance. On the other hand, simulator trials can assess the 'products' of ADM performance including the situation assessment, risk management, and response time in real-time setting, however, they had limitations for analyzing the cognitive processes of pilots. Simulator trials allowed the behavior of pilots to be evaluated and the outcomes of their decision-making processes to be observed, but did not allow any insight into the cognitive processes.

The results suggested that the ADM training programs did improve pilots' situation assessment and risk management. However, the response times of the trained group were longer than the untrained group in all three simulator trials. There were two possible explanations; firstly, as pilots were not familiar with the ADM mnemonics, they spent some time applying these steps. With more opportunity to practice these ADM mnemonics, their response times may improve. Secondly, it may have been that the cognitive processes of situation assessment and risk management took more time.

CHAPTER VI

Conclusions and Recommendations

6.1 Overview

O'Hare (2003) reviewed aeronautical decision-making and came to the conclusion 'it is difficult to think of any single topic that is more central to the question of effective human performance in aviation than that of decision-making'. This chapter draws conclusions from the three studies conducted and provides recommendations for improving the safety of military aviation, with focus on enhancing the quality of pilots' Aeronautical Decision-making.

6.2 Conclusions

1. To improve aviation safety, the precise identification of the role of human error in accidents and pinpointing of human factors problems, especially with regard to pilot's decision errors, is imperative to develop effective intervention strategies. The HFACS framework can provide both a theoretical and practical foundation for describing the multiple components that are required for effective accident investigation. It helped identify the ADM training needs for developing a training program to improve pilots' in-flight decision-making.
2. The HFACS framework has proved to be a useful tool for accident analysis. It has high inter-rater reliability in each individual category. This research has also demonstrated that the HFACS framework, originally developed for analysis of US

military aviation mishaps, also can be used to analyze accident data from the R.O.C. Air Force.

3. There is now empirical evidence of how actions and decisions at higher levels in the organization promulgate throughout the R.O.C. Air Force to result in operational errors and accidents. This has not previously been done with data analyzed using HFACS. 'Decision errors' were associated with very high percentage (42.6%) of aircrew-related accidents. These had an intimate relationship with 'crew resource management' (level-2), and subsequently with 'inadequate supervision' (level-3) and 'organizational climate' and 'organizational process' (level-4). There were clearly defined, statistically-described paths that related errors at level-1 (the operational level) with inadequacies at both the immediately adjacent and more remote levels in the organization.

4. This research supports Reason's (1990) model, upon which the HFACS framework is based, of active failure resulting from latent conditions in the organization. Fallible decisions of upper-level management can directly affect the middle level of supervisory practices, creating 'preconditions for unsafe acts' which impairs the performance of pilots, leading to accidents.

5. There are a number of strategies embodied in mnemonics developed by aviation researchers and used by pilots that help guide and structure decision-making. The common aim of these techniques is to form a systematic approach to decision-making that should be less affected by the human nature and should also reduce the cognitive work for pilots. Two ADM training mnemonics formed a suitable basis for decision-making training which encompassed the requirements of the six basic decision making situations. SHOR was rated as being the best ADM mnemonic method in time-limited and critical, urgent situations; DESIDE was

regarded as superior for knowledge-based decisions which required more comprehensive considerations but which also had the time available to do so. The ADM training program based on these mnemonics improved pilots' in-flight decision-making performance. Improvements of pilots' situation assessment and risk management were obtained, but at the expense of response time. To maximize ADM training benefits, more practice in the simulator may help minimize response time.

6. The most significant aspect of decision-making is situation assessment. This is a precursor for situation awareness, which itself is the precursor for all tasks of decision-making (Lipshitz, 1993). In the tactical environment, effective decision-making is highly dependent on situation awareness for safety of flight operations. This research demonstrated that pilots conducted situation assessment for making decision by assessing of the precipitating threats and evaluating potential courses of action. Pilots needed to perform mental simulation to assess the situations for impending threats and managing risks to gain the situation awareness for making decision in the dymanic environment, although it might have delay for response time. It is possible that further training and practice may subsequently increase the speed of the decision-making process. As pilots were not familiar with the ADM mnemonics, they spent more time applying these steps. After they have had more opportunity to practice these ADM mnemonics, their response times may be quicker. However, it may simply be that thinking more when conducting situational assessment and risk management takes more time and it is this increased time dedicated to evaluating the problem that leads to superior performance

6.3 Recommendations

To improve aviation safety of R.O.C. Air Force, it is necessary to specific the aeronautical decision-making training for military pilots. It is recommended that pilots have little control over the uncertain tactical situations which may confront them when flying a fighter aircraft. Therefore, it is important to train novice pilots with the relevant strategies for making appropriate decisions in different types of tactical environments. The findings suggest that a simple, short, cost-effective training programme in the appropriate use of ADM mnemonic methods will produce significant gains in flight safety. Such a course may easily be integrated into current CRM or simulator-based training programs. There are three recommendations for further research.

1. Even though HFACS proved to be a suitable tool for both accident investigation and accident prevention, there is still a need for further research on its cross-cultural application. The accidents and incidents analysed all occurred in the R.O.C. Air Force, a collectivist and high power-distance culture (Hofstede, 2001). The pattern of statistical relationships between categories in the different levels of the HFACS may be culturally specific, however it is likely that other, similar patterns of relationship may be obtained in different cultures providing further empirical evidence to support the HFACS methodology.
2. There is also a need to investigate if additional practice in the application of the ADM mnemonic methods in a flight simulator increases the speed of decision-making. The guideline for practicing ADM mnemonics should simply specify

applying SHOR in urgent situations with little time and using DESIDE when time is available for comprehensive consideration situations. They may be no requirement to appraise tranees of all six different basic types of decision.

3. Training evaluation involved a series of levels, from the assessment of pilots' reactions to training, through measurement of individual changes in knowledge and behaviour, to the measurement of organizational change (Kirkpatrick, 1976). Further research is required that to evaluate longer-term effectiveness of such ADM training courses to see if it translates into improved decision-making behaviour during day-to-day operations which, ultimately also results in a reduction in the accident rate attributable to poor decision-making in the future.

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Appendix A – Evaluating the Suitability of ADM Mnemonics

狀況：編隊高速滾行中長機放棄起飛，僚機之處置(No. 2 is making the decision as the leader abandons a tactical formation take-off during a taxi run at 145 knots)

一、狀況(Scenario)：

於桃園基地中尉飛行官駕 F–5E 00 號機，外型中線 150 加侖任 AI 攔截二號機，1350 進跑道試車一切正常，1351 與長機編隊起飛，滾行中飛機有超前長機趨勢，收油門至最小 A/B 位置後可保持正常編隊，至 145 浬突聞長機呼叫 Lead 放棄起飛？ (A Lieutenant pilot flying an F-5E (No. 2) equipped with a 150-gallon-tank in centerline was ready to take off with the Leader (No. 1). During the take-off run, in order to maintain the normal formation position, No.2 pulled the throttle to minimum A/B (after burner) because of a tendency to pass Leader when the Leader called ~~out~~ “Abort” at 145 knots of ground speed.)

二、問題(Question)：

請問貴官當時為二號機應如何處置？ (What would you do if you were the No.2?)

（請做完後面五頁之後，再填寫此處-Please read the questions on the following 5-pages first, and then answer the questions here).

三、針對「編隊高速滾行中長機放棄起飛，僚機之處置 」的狀況

(1) SHOR, (2) PASS, (3) FOR-DEC, (4) SOAR, (5) DESIDE

此五種「飛行決策」訓練方式，您認爲哪一種是最佳之訓練方式？理由爲何？

(Which ADM mnemonic is the best approach for this situation? And Why?)

SHOR「飛行決策訓練」--SHOR ADM training

(S) 刺激 **(Stimuli,** 指飛行員感受到外在環境之變化-Pilot perceives surroundings change.)

(1) 編隊起飛位置超前長機（Formation take-off position over leader）。

(2) 滾行速度 145 浬，長機呼叫放棄起飛（Rolling speed 145 knots,leader calling “abort”）。

(H) 假設 **(Hypotheses,** 針對新訊息（刺激）提假設，例如是否有安全顧慮？-Hypotheses for new information (stimulation), for example, “Is anything dangerous?”)

(1) 長機有問題（Something is wrong with leader）。

(2) 長機對我造成安全顧慮（I need to think about the potential risk for me with the situation of leader）。

(O) 選擇 **(Options,** 現在最重要的是作什麼？該如何做？-What thing is the first priority to do now? How to do it ?)

(1) 收油門維持正常編隊位置，與長機一起放棄起飛（Reducing throttle to maintain a normal formation position, abandoned taking-off with leader）。

(2) 維持半邊跑道正常操作，繼續單機起飛（Maintain half-runway normal operation, continued single take-off）。

(R) 行動反應 **(Response,** 採取行動，做什麼？如何做？何時做？到哪裡？**...**-To take action. What to do? How to do it? When to do it? Where to go now?...)

繼續起飛（Continuing take-off）。

(1) **在此種放棄起飛的飛行情境中，您覺得 SHOR「飛行決策訓練」之「風險評估」的效率如何？**（效率很高 9，尚可接受 5，效率很低 1，請圈選一個數字）

9　8　7　6　5　4　3　2　1

In this scenario, what do you think about the effectivness of SHOR for situation assessment? (Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

(2) **在此種放棄起飛的飛行情境中，您覺得 SHOR「飛行決策訓練」之「危機管理」的效率如何？**（效率很高 9，尚可接受 5，效率很低 1，請圈選一個數字）

9　8　7　6　5　4　3　2　1

In this scenario, what do you think about the effectiveness of SHOR for risk management? (Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

(3) **在此種放棄起飛的情境中，您覺得 SHOR「飛行決策訓練」之「時間管理」的效率如何（能否即時應變）？**（效率很高 9，尚可接受 5，效率很低 1，請圈選一個數字）

9　8　7　6　5　4　3　2　1

In this scenario, what do you think about the effectivness of SHOR for response time? (Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

(4) 在此種飛行情境中，您覺得 SHOR「飛行決策訓練」之「可行性」如何？
（可行性很高 9，尚可接受 5，可行性很低 1，請圈選一個數字）

9　8　7　6　5　4　3　2　1

In this scenario, what do you think about the overall applicability of SHOR?

(Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

****

PASS 「飛行決策訓練」-PASS ADM training

(P) 確認問題 (Problem identification, 辨明目前所處的環境及問題所在-To identify surroundings and problems at present.)

(1) 長機加速較正常情況慢(Leader's acceleration is slower than normal.)。

(2) 長機呼叫放棄起飛(Leader calls out "abort" by radio.)。

(3) 二號機操作狀況正常(No. 2's operation is normal.)。

(A) 取得訊息 (Acquire information, 蒐集與問題有關之訊息-To collect information concerning problems.)

(1) 聽到長機呼叫放棄起飛(Listen "abort" from leader.)。

(2) 看到剩餘跑道與速度均足以安全起飛(Remaining runway is long enough for safe take-off.)。

(S) 檢驗策略 (Survey strategy, 檢驗解決問題之相關策略之優點與缺點- To survey the strength and weakness of strategies for solving problems.)

(1) 與長機一同放棄起飛將造成後續緊急處置之相互干擾(To abort take-off with leader will interrupt the following emergency operation.)。

(2) 二號機尚可維持半邊跑道加油門繼續起飛(No. 2 continues to take off with half runway.)。

(S) 選擇策略 (Select strategy, 選擇最佳策略並執行- To choice the most proper strategy and take action.)

維持半邊跑道加油門繼續起飛(Contiue to take off with half runway.)。

(1) **在此種放棄起飛的飛行情境中，您覺得 PASS「飛行決策訓練」之「風險評估」的效率如何？**（效率很高 9，尚可接受 5，效率很低 1，請圈選一個數字）

9 8 7 6 5 4 3 2 1

In this scenario, what do you think about the effectivness of PASS for situation assessment? (Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

(2) **在此種放棄起飛的飛行情境中，您覺得 PASS 「飛行決策訓練」之「危機管理」的效率如何？**（效率很高 9，尚可接受 5，效率很低 1，請圈選一個數字）

9 8 7 6 5 4 3 2 1

In this scenario, what do you think about the effectiveness of PASS for risk management? (Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

(3) 在此種放棄起飛的情境中，您覺得 PASS 「飛行決策訓練」之「時間管理」的效率如何（能否即時應變）？（效率很高9，尚可接受5，效率很低1，請圈選一個數字）

9 8 7 6 5 4 3 2 1

In this scenario, what do you think about the effectivness of PASS for response time?
(Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

(4) 在此種飛行情境中，您覺得 PASS「飛行決策訓練」之「可行性」如何？
（可行性很高 9，尚可接受 5，可行性很低 1，請圈選一個數字）

9 8 7 6 5 4 3 2 1

In this scenario, what do you think about the overall applicability of PASS?
(Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

****

FOR-DEC「飛行決策訓練」-FOR-DEC ADM training

(F) 實況 (<u>F</u>acts, 此時此地發生什麼狀況？-What's happening now?)
  (1) 長機速度有異常現象(Something wrong with leader's speed.)。
  (2) 長機於速度 145 浬時呼叫放棄起飛(Rolling speed 145 knots, leader calling "abort".)。

(O) 選項 (<u>O</u>ptions, 我有什麼樣的對應策略可選擇？- What strategies can be selected?)
  (1) 與長機一起放棄起飛(Abort take-off with leader.)。
  (2) 保持半邊跑道操作繼續起飛(Continuing to take off with half runway.)。

(R) 危機與優勢 (<u>R</u>isk & Benefits, 不同策略有何不同的潛在危機與優勢？- Are there any risk and benefits for different strategies? **)**
  (1) 過份執著編隊位置，將導致剩餘跑道不足到達起飛速度，危及長機與自身安全(Keeping formation position will make remaining runway not enough to achieve the required speed for take off which results in dangerous situation for leader and itself.)。
  (2) 依滾行距離、速度及主要發動機儀表可研判自身飛機正常(Pilot can judge whether the aircraft is normal or not according to rolling distance, speed and engine's instruments.)。
  (3) 到達起不起飛決定點之前，先維持正常編隊位置(Before achieving Go No Go, it is first to keep formation position normal.)。
  (4) 長機決定放棄起飛後，對二號機的後續操作有較明確的參考(Leader's decision to abort take-off gives No. 2 a more explicit reference for the following operation.)。
  (5) 長機決定放棄起飛後，二號機的速度與剩餘跑道均支持做繼續起飛的決心(After leader aborts take-off, the speed and remaining runway support No.2 to keep the operation of take-off.)。
  (6) 二號機若也放棄起飛將導致兩架飛機後續處置相互衝突的可能性，憑增危險因素(If No. 2 makes the same decision to abort take-off, it will increase the interruptions and dangers to both ~~of~~ aircrafts.)。

(D) 決心 (<u>D</u>ecision, 選定一最佳之策略- To select the best strategy.)
  二號機以維持半邊跑道繼續起飛爲最安全之決定(To continue to take off with half runway is the safest decision.)。

(E) 執行 (<u>E</u>xecution, 執行此最佳策略並注意何時做？做什麼？如何做？-To execute this strategy and watch out for when, what and how to do it.**)**
  保持半邊跑道滾行，油門於最大位置，依攜帶外型的起飛速度操作(No. 2 pushes throttle to the maximum and continues to take off with half side of runway with the suggested speed.)。

(C) 檢驗 (<u>C</u>heck, 檢驗每個動作執行後對飛行安全所造成之影響- To check if each operation influences flight safety.)
  (1) 保持在半邊跑道的中線上(To keep aircraft on centerline of half runway.)。
  (2) 注意剩餘跑道(To watch out the remaining runway.)。
  (3) 返降及轉降的可能性分析(To analyze the probability of RTB-return to base or transfer to the other bases.)。

(1) 在此種放棄起飛的飛行情境中，您覺得 FOR-DEC 「飛行決策訓練」之「風險評估」的效率如何？（效率很高 9，尚可接受 5，效率很低 1，請圈選一個數字）

9 8 7 6 5 4 3 2 1

In this scenario, what do you think about the effectivness of FOR-DEC for situation assessment?
(Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

(2) 在此種放棄起飛的飛行情境中，您覺得 FOR-DEC 「飛行決策訓練」之「危機管理」的效率如何？（效率很高 9，尚可接受 5，效率很低 1，請圈選一個數字）

9 8 7 6 5 4 3 2 1

In this scenario, what do you think about the effectiveness of FOR-DEC for risk management?
(Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

(3) 在此種放棄起飛的情境中，您覺得 FOR-DEC 「飛行決策訓練」之「時間管理」的效率如何（能否即時應變）？（效率很高 9，尚可接受 5，效率很低 1，請圈選一個數字）

9 8 7 6 5 4 3 2 1

In this scenario, what do you think about the effectivness of FOR-DEC for response time?
(Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

(4) 在此種飛行情境中，您覺得 FOR-DEC「飛行決策訓練」之「可行性」如何？
（可行性很高 9，尚可接受 5，可行性很低 1，請圈選一個數字）

9 8 7 6 5 4 3 2 1

In this scenario, what do you think about the overall applicability of FOR-DEC?
(Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

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SOAR「飛行決策訓練」-SOAR ADM training

(S) 情境 (Situation, 目前飛機、飛行環境、與飛行員之狀況如何？-What are the situations of aircrafts, surroundings and pilots?)

(1) 長機加速異常(Leader's acceleration is abnormal.)。

(2) 長機於速度 145 浬時呼叫放棄起飛(When rolling speed 145 knots, leader calls out "abort".)。

(O) 選項 (Options, 評估可選擇之策略有哪些？執行後會有哪些後果？選擇最佳策略-To evaluate feasible strategies, to figure out the possible results after executeing and to select the best strategy.)

(1) 收油門減速維持編隊起飛正常位置，俟情況明確時再做後續處理(No.2 reduces speed and maintains normal formation position till the situation is more explicit, and then operates the following procedures.)。

(2) 仍維持正常油門位置，預備呼叫"二號機衝出"(To keep throttle position normal and prepare to call out "No. 2 overshoot".)。

(3) 長機放棄起飛後，二號機維持半邊跑道繼續起飛操作或放棄起飛(After leader aborted take-off, No. 2 continues or aborts the operation for take-off.)。

(A) 行動 (Act, 執行所選擇之最佳策略，並注意對飛行情境所造成之變化-To execute the best strategy and watch out surroundings' change.)

(1) 長機的決心、是否對我造成危害、剩餘跑道及滾行速度是後續行動的依據(The following operation is based on what the leader's determination is, if the situation is harmful to me, how long the remaining runway is and what the speed is.)。

(2) 維持半邊跑道繼續起飛爲最佳策略(To continue to take off with half runway is the safest strategy.)。

(R) 重複 (Repeat, 重複評估飛機、飛行環境、與飛行員之狀況，選擇並執行最佳策略 -Repeat evaluation for aircraft, flight surroundings and pilots' condition; select and execute the best strategy.)

(1) 在起不起飛決定點之前，重複研判與長機的編隊位置、剩餘跑道的位置、速度檢查及長機決心爲何(Before the decision of Go-No Go, to repeat evaluation for formation position, runway's remaining length, speed and leader's decision.)。

(2) 二號機維持半邊跑道繼續起飛，俟耗油至安全存量始落地(No. 2 continues to take off with half runway until safe amount of fuel and then landing.)。

(1) **在此種放棄起飛的飛行情境中，您覺得 SOAR「飛行決策訓練」之「風險評估」的效率如何？**（效率很高 9，尚可接受 5，效率很低 1，請圈選一個數字）

9 8 7 6 5 4 3 2 1

In this scenario, what do you think about the effectivness of SOAR for situation assessment? (Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

(2) 在此種放棄起飛的飛行情境中，您覺得 SOAR「飛行決策訓練」之「危機管理」的效率如何？（效率很高 9，尚可接受 5，效率很低 1，請圈選一個數字）

9 8 7 6 5 4 3 2 1

In this scenario, what do you think about the effectiveness of SOAR for risk management?

(Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

(3) 在此種放棄起飛的情境中，您覺得 SOAR「飛行決策訓練」之「時間管理」的效率如何（能否即時應變）？（效率很高 9，尚可接受 5，效率很低 1，請圈選一個數字）

9 8 7 6 5 4 3 2 1

In this scenario, what do you think about the effectivness of SOAR for response time?

(Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

(4) 在此種飛行情境中，您覺得 SOAR「飛行決策訓練」之「可行性」如何？
（可行性很高 9，尚可接受 5，可行性很低 1，請圈選一個數字）

9 8 7 6 5 4 3 2 1

In this scenario, what do you think about the overall applicability of SOAR?

(Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

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DESIDE「飛行決策訓練」-DESIDE ADM training

(D) 察覺 (Detect, 覺察飛行環境與飛機狀況是否有異常-To detect if any unusual condition about surroundings and aircraft.)

(1) 編隊參考點位移（The formation checkpoint changed）。

(2) 長機加速異常並呼叫放棄起飛（Leader accelerated unnormally and clled “abort”）。

(E) 估計 (Estimate,根據所覺察之飛行狀況，評估對飛安之影響-To evaluate the influence on flight safety based on flying condition.)

(1) 依滾行距離與經驗，長機速度可能有問題（According to the rolling distance and experience, something would be wrong with leader’s speed）。

(2) 在到達起不起飛決定點之前先維持正常編隊位置，尙不構成明顯危（Maintaining formation position before arriving the critical speed, there was no significant risk）。

(3) 長機放棄起飛且對我無危害時，依自身速度與跑道剩餘距離，應以繼續起飛較爲安全（If there was no risk to me when leader abandoned take-off, it is safer to continue taking-off）。

(S) 設立安全目標 (Set Safety Objectives, 尋找是否有較好的解決策略？-Are there any more proper strategy?)

(1) 先維持編隊起飛正常位置（Maintaining normal formation position）。

(2) 與長機隔離，以維安全（Separating a room to keep safe）。

(I) 確認 (Identify, 是否有足夠的時間收集更多訊息，並評估行動策略-Is time enough to collect more information and evaluate strategies.)

(1) 長機放棄起飛指令（The “abandon” instruction of leader）。

(2) 目前速度多少（What is the current speed now）。

(3) 攜帶外型之起飛速度（The take-off speed of present equipmented form）。

(4) 剩餘跑道（The rest of the runway）。

(D) 行動 (Do, 執行最佳行動策略-Take action.)

(1) 維持半邊跑道滾行，油門最大（Maintaining half-runway rolling,max-A/B）。

(2) 依技令指示速度起飛（Obeying the take-off speed that T.O instructed

(E) 評量 (Evaluate, 評量行動後對飛行安全有何影響？並繼續再注意覺察飛行情境之變化-To evaluate the influence after taking action and continue watching for the changes of flying condition.)

(1) 有無保持半邊跑道中線（Maintaining the center-line of the half-runway or not）？

(2) 剩餘跑道是否足以安全起飛（Is it possible for taking-off with the rest of the runway）？

(3) 起飛速度是否依技令操作（Is the the take-off speed following on T.O instruction）？

(4) 轉降外場或返降之評估（The evaluation of return to base or land to other bases）？

(1) 在此種放棄起飛的飛行情境中，您覺得 DESIDE「飛行決策訓練」之「風險評估」的效率如何？（效率很高 9，尚可接受 5，效率很低 1，請圈選一個數字）

9 8 7 6 5 4 3 2 1

In this scenario, what do you think about the effectivness of DESIDE for situation assessment?

(Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

(2) 在此種放棄起飛的飛行情境中，您覺得 DESIDE「飛行決策訓練」之「危機管理」的效率如何？（效率很高 9，尚可接受 5，效率很低 1，請圈選一個數字）

9 8 7 6 5 4 3 2 1

In this scenario, what do you think about the effectiveness of DESIDE for risk management?

(Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

(3) 在此種放棄起飛的情境中，您覺得 DESIDE「飛行決策訓練」之「時間管理」的效率如何（能否即時應變）？（效率很高 9，尚可接受 5，效率很低 1，請圈選一個數字）

9 8 7 6 5 4 3 2 1

In this scenario, what do you think about the effectivness of DESIDE for response time?

(Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

(4) 在此種飛行情境中，您覺得 DESIDE「飛行決策訓練」之「可行性」如何？（可行性很高 9，尚可接受 5，可行性很低 1，請圈選一個數字）

9 8 7 6 5 4 3 2 1

In this scenario, what do you think about the overall applicability of DESIDE?

(Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

****

狀況：飛機鼻輪甫離地遭遇單發動機故障(One engine out just as the nose gear leaves the ground.)

一、狀況：

於桃園基地訓練，中尉學官駕 F–5E 0000 號機，中線 150 加侖外型，任 GCI 課目四號機，於起飛滾行中，發動機加速正常，165 浬帶桿飛機鼻輪始離地時，忽聞右發動機〝碰〞一聲，推力消失。 (A Lieutenant pilot flying an F-5E equipped with a 150-gallon-tank in centerline, after a normal roll, was ready to take off with a speed of 165 knots. Just as the nose gear took off, there was a sudden loud bang from the right engine and then the engine went out.)

二、問題：請問貴官的處置如何？ (What would you do if you were the pilot?)

（請做完後面五頁之後，再填寫此處- Please read the questions on the following 5-pages first, and then answer the questions here)

三、針對「飛機鼻輪甫離地遭遇單發動機故障」的狀況

(1) SHOR, (2) PASS, (3) FOR-DEC, (4) SOAR, (5) DESIDE

此五種「飛行決策」訓練方式，您認爲哪一種是最佳之訓練方式？理由爲何？

(Which ADM mnemonic is the best approach for this situation? And Why?)

SHOR「飛行決策訓練」

(S) 刺激 (Stimuli, 指飛行員感受到外在環境之變化-Pilot perceives surroundings change.)

(1) 起飛姿態已建立(The attitude for taking off had been set up.)。

(2) 右發動機有聲響且推力消失(Right engine had blast sound and then power off.)。

(3) 左發動機推力正常(Left engine was normal.)。

(4) 起飛速度變化(Speed for taking off was changed.)。

(H) 假設 (Hypotheses, 針對新訊息（刺激）提假設，例如是否有安顧慮？-Hypotheses for new information (stimulation), for example, "Is anything dangerous?"**)**

右發動機受外物損傷或內物損傷導致失效(Assumed that right engine's power off was resulted from FOD or IOD.)。

(O) 選擇 (Options, 現在最重要的是作什麼？該如何做？-What thing is first priority to do now? How to do?**)**

(1) 立即放棄起飛(Abort take-off immediately.)。

(2) 以單發動機繼續起飛(To continue taking off with single engine.)。

(3) 是否選擇彈射跳傘(Eject or not?)。

(R) 行動反應 (Response, 採取行動，做什麼？如何做？何時做？到哪裡？**…**-What thing is first priority to do now? How to do?**)**

(1) 以單發動機起飛，165 浬的速度足以繼續起飛，且已建立起飛姿態(Continue taking off with single engine)。

(2) 剩餘跑道與目前速度雖可放棄起飛，但後續無法安全停住飛機的危險性高(The remaining runway and present speed are enough to abort take-off, but the risk to stop aircraft safely is high.)。

(1) **在此種放棄起飛的飛行情境中，您覺得 SHOR「飛行決策訓練」之「風險評估」的效率如何？**（效率很高 9，尚可接受 5，效率很低 1，請圈選一個數字）

9　8　7　6　5　4　3　2　1

In this scenario, what do you think about the effectivness of SHOR for situation assessment? (Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

(2) **在此種放棄起飛的飛行情境中，您覺得 SHOR「飛行決策訓練」之「危機管理」的效率如何？**（效率很高 9，尚可接受 5，效率很低 1，請圈選一個數字）

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In this scenario, what do you think about the effectiveness of SHOR for risk management? (Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

(3) 在此種放棄起飛的情境中，您覺得 SHOR「飛行決策訓練」之「時間管理」的效率如何（能否即時應變）？（效率很高 9，尚可接受 5，效率很低 1，請圈選一個數字）

9 8 7 6 5 4 3 2 1

In this scenario, what do you think about the effectivness of SHOR for response time?

(Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

(4) 在此種飛行情境中，您覺得 SHOR「飛行決策訓練」之「可行性」如何？（可行性很高 9，尚可接受 5，可行性很低 1，請圈選一個數字）

9 8 7 6 5 4 3 2 1

In this scenario, what do you think about the overall applicability of SHOR?

(Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

****

PASS「飛行決策訓練」

(P) **確認問題** **(Problem identification,** 辨明目前所處的環境及問題所在-To identify surroundings and problems at present.)

起飛姿態建立、鼻輪離地時，右發動機失效(When the attitude for taking off had been set up, right engine's power out.)。

(A) **取得訊息** **(Acquire information,** 蒐集與問題有關之訊息-To collect information concerning problems.**)**

(1) 起飛姿態已經建立且鼻輪已離地(The attitude for taking off had been set up and nose wheel had been departed from runway.)。

(2) 右發動機疑因外物損傷或內物損傷失效(Right engine failed(is out) probably because of FOD or IOD.)。

(3) 左發動機正常(Left engine is normal.)。

(S) **檢驗策略** **(Survey strategy,** 檢驗解決問題之相關策略之優點與缺點- To survey the strengths and weaknesses of strategies for solving problems.**)**

(1) 立即放棄起飛(Abort take-off immediately.)。

(2) 仍保持起飛姿態繼續起飛(Maintain the attitude to take off.)。

(S) **選擇策略** **(Select strategy,** 選擇最佳策略並執行- To choose the best strategy and take action.**)**

保持單發動機起飛姿態減低仰角並增加速度(To maintain the attitude to take off with single engine and to increase speed with little pitching angle.)。

(1) 在此種放棄起飛的飛行情境中，您覺得 PASS「飛行決策訓練」之「風險評估」的效率如何？（效率很高 9，尚可接受 5，效率很低 1，請圈選一個數字）

9　8　7　6　5　4　3　2　1

In this scenario, what do you think about the effectivness of PASS for situation assessment? (Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

(2) 在此種放棄起飛的飛行情境中，您覺得 PASS 「飛行決策訓練」之「危機管理」的效率如何？（效率很高 9，尚可接受 5，效率很低 1，請圈選一個數字）

9　8　7　6　5　4　3　2　1

In this scenario, what do you think about the effectiveness of PASS for risk management? (Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

(3) 在此種放棄起飛的情境中，您覺得 PASS 「飛行決策訓練」之「時間管理」的效率如何（能否即時應變）？（效率很高 9，尚可接受 5，效率很低 1，請圈選一個數字）

9 8 7 6 5 4 3 2 1

In this scenario, what do you think about the effectivness of PASS for response time?

(Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

(4) 在此種飛行情境中，您覺得 PASS「飛行決策訓練」之「可行性」如何？

（可行性很高 9，尚可接受 5，可行性很低 1，請圈選一個數字）

9 8 7 6 5 4 3 2 1

In this scenario, what do you think about the overall applicability of PASS?

(Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

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FOR-DEC「飛行決策訓練」

(F) 實況 (Facts, 此時此地發生什麼狀況？-What's happening now?)

(1) 起飛姿態已建立(The attitude for taking off had been set up.)。

(2) 右發動機有聲響且推力消失(Right engine had blast sound and power was off.)。

(3) 左發動機推力正常(Left engine's power was normal.)。

(4) 飛機速度超過起不起飛決定速度(The aircraft speed was more than go-no go speed.)。

(O) 選項 (Options, 我有什麼樣的對應策略可選擇？- What strategies can be selected?)

(1) 立即放棄起飛(Abort take-off immediately.)。

(2) 仍保持起飛姿態繼續起飛(Maintain the attitude to take off)。

(R) 危機與優勢 (Risk & Benefits, 不同策略有何不同的潛在危機與優勢？- Are there any risks and benefits for different strategies?)

(1) 放棄起飛後續操作，使用煞車量未知；能否安全停住飛機未知；撞攔截網安全與否未知(The following operation after aborting take-off will be unknown; it will be unknown to stop aircraft safely or to use safety net.)。

(2) 按技令，此時繼續起飛亦屬合於規訂，但帶故障飛行有風險(單發動機的可靠度)(According to the technical order, to take off is well, but it has risk to continue flying with failings.)。

(3) 按後續操作，無論起飛與落地的要領均曾於模擬機與實際飛訓中演練過，飛行員所能掌控的因素較多(For the following operation, no matter take-off or landing, which were practiced with simulator or real flight, the factors pilot can handle are no problem.)。

(D) 決心 (Decision, 選定一最佳之策略- To select the best strategy.)

保持單發動機起飛(To continue take-off with single engine.)。

(E) 執行 (Execution, 執行此最佳策略並注意何時做？做什麼？如何做？-To execute this strategy and watch out for when, what and how to do it.)

利用剩餘跑道減低仰角並增加空速執行單發動機起飛之操作(To maintain the attitude to take off with single engine and to increase speed with little pitching angle.)。

(C) 檢驗 (Check, 檢驗每個動作執行後對飛行安全所造成之影響- To check if each operation influences flight safety.)

(1) 起飛仰角是否過大或過小？(Is take-off angle over or under?)

(2) 左右配平是否依實際動力分佈情況調整？(Are right and left trimmers adjusted with power distribution?)

(3) 收起落架時是否遵守 175 至 210 浬速限？(Are landing gears up with the speed limitation between 175 and 210 knots?)

(4) 襟翼在外速限？(What is the speed limitation for flaps?)

(5) 是否爬升至 2000 呎安全彈跳高度？(Does aircraft climb to 2000 feet for eject?)

(6) 是否隨時注意操作柔和？(Operates smoothly at all time?)

(7) 本場單發動機航線爲何？(What is the base pattern for single engine landing?)

(8) 左發動機動力是否維持正常？(Is left engine power normal?)

(9) 彈射跳傘的要領爲何？(What are the tips for bail out?)

(1) **在此種放棄起飛的飛行情境中，您覺得 FOR-DEC 「飛行決策訓練」之「風險評估」的效率如何？**（效率很高 9，尚可接受 5，效率很低 1，請圈選一個數字）

9 8 7 6 5 4 3 2 1

In this scenario, what do you think about the effectivness of FOR-DEC for situation assessment? (Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

(2) 在此種放棄起飛的飛行情境中，您覺得 FOR-DEC 「飛行決策訓練」之「危機管理」的效率如何？（效率很高 9，尚可接受 5，效率很低 1，請圈選一個數字）

9 8 7 6 5 4 3 2 1

In this scenario, what do you think about the effectiveness of FOR-DEC for risk management? (Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

(3) 在此種放棄起飛的情境中，您覺得 FOR-DEC 「飛行決策訓練」之「時間管理」的效率如何（能否即時應變）？（效率很高 9，尚可接受 5，效率很低 1，請圈選一個數字）

9 8 7 6 5 4 3 2 1

In this scenario, what do you think about the effectivness of FOR-DEC for response time? (Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

(4) 在此種飛行情境中，您覺得 FOR-DEC「飛行決策訓練」之「可行性」如何？（可行性很高 9，尚可接受 5，可行性很低 1，請圈選一個數字）

9 8 7 6 5 4 3 2 1

In this scenario, what do you think about the overall applicability of FOR-DEC? (Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

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SOAR「飛行決策訓練」

(S) 情境 (Situation, 目前飛機、飛行環境、與飛行員之狀況如何？-What are the situations of aircrafts, surroundings and pilots?)

(1) 起飛姿態已建立。(The attitude of take-off has been set up.)

(2) 右發動機有聲響且推力消失。(Right engine had blast sound and power was out.)

(3) 左發動機推力正常。(Left engine's power is normal.)

(4) 剩餘跑道與滾行速度均在起不起飛決定點之前。(Remanding runway distance and rolling speed are both before go no go point.)

建議(4) 尚未到達起不起飛點【拒絕起飛速度】。(Present position is before the go no go point【refuse taking off speed.】)—起不起飛點：單發動機飛機；拒絕起飛速度：雙發動機

(O) 選項 (Options, 評估可選擇之策略有哪些？執行後會有哪些後果？選擇最佳策略-To evaluate feasible strategies, to figure out the possible results after executeing and to select the best strategy. **)**

(1) 立即放棄起飛。(Abort take-off immediately.)

(2) 仍保持起飛之企圖。(To maintain the attempt to take-off.)

(A) 行動 (Act, 執行所選擇之最佳策略，並注意對飛行情境所造成之變化-To execute the best strategy and watch out surroundings' change. **)**

單發動機繼續起飛，減低仰角並利用剩餘跑道增加空速。(To continue the operation of take-off with single engine, reduce pitching angle and make use of the remaining runway to increase speed.)

(R) 重複評估情境與選項 (Repeat, 重複評估飛機與飛行環境，選擇並執行最佳策略 -Repeat evaluation for aircraft, flight surroundings and pilots' condition; select and execute the best strategy. **)**

(1) 單發動機的可靠度。(The single engine's reliability.)

(2) 飛機之速度、高度、與姿態。(Aircraft's speed, altitude and attitude.)

(1) **在此種放棄起飛的飛行情境中，您覺得 SOAR「飛行決策訓練」之「風險評估」的效率如何？**（效率很高 9，尚可接受 5，效率很低 1，請圈選一個數字）

9　8　7　6　5　4　3　2　1

In this scenario, what do you think about the effectivness of SOAR for situation assessment? (Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

(2) 在此種放棄起飛的飛行情境中，您覺得 SOAR「飛行決策訓練」之「危機管理」的效率如何？（效率很高 9，尚可接受 5，效率很低 1，請圈選一個數字）

9 8 7 6 5 4 3 2 1

In this scenario, what do you think about the effectiveness of SOAR for risk management?
(Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

(3) 在此種放棄起飛的情境中，您覺得 SOAR「飛行決策訓練」之「時間管理」的效率如何（能否即時應變）？（效率很高 9，尚可接受 5，效率很低 1，請圈選一個數字）

9 8 7 6 5 4 3 2 1

In this scenario, what do you think about the effectivness of SOAR for response time?
(Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

(4) 在此種飛行情境中，您覺得 SOAR「飛行決策訓練」之「可行性」如何？
（可行性很高 9，尚可接受 5，可行性很低 1，請圈選一個數字）

9 8 7 6 5 4 3 2 1

In this scenario, what do you think about the overall applicability of SOAR?
(Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

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DESIDE「飛行決策訓練」

(D) 察覺 (Detect, 覺察飛行環境與飛機狀況是否有異常-To detect if any unusual condition about surroundings and aircraft.)

起飛姿態建立、鼻輪離地時，突聞右發動機有撞擊聲隨即推力消失，左發動機推力正常。(When the attitude for taking-off had been set up and nose gear left runway, right engine had blast sound and power was out, but left engine power was normal.)

(E) 估計 (Estimate, 根據所覺察之飛行狀況，評估對飛安之影響-To evaluate the influence on flight safety based on flying condition.)

研判右發動機應爲外物損傷或內物損傷造成推力消失。(The right engine should be damaged by FOD or IOD.)

(S) 設立安全目標 (Set Safety Objectives, 尋找是否有較好的解決策略？-Are there any more proper strategies?)

(1) 立即放棄起飛將飛機安全煞住。(Abort take-off and stop the aircraft immediately.)

(2) 利用剩餘跑道安全起飛。(To make use of the remaining runway to take off safely.)

(I) 確認 (Identify, 是否有足夠的時間收集更多訊息，並評估行動策略-Is time enough to collect more information and evaluate strategies.)

(1) 起飛姿態已經建立且已到達起飛速度。(The attitude for taking-off had been set up and the speed was enough for taking off.)

(2) 左發動機能提供繼續起飛之推力。(The left engine could provide enough power to take off.)

(3) 剩餘跑道與目前速度仍足以安全放棄起飛。(The remaining runway and the speed were enough for aborting take-off safely.)

(D) 行動 (Do, 執行最佳行動策略-Take action.)

執行單發動機繼續起飛。(Take action for taking off with a single engine.)

(E) 評量 (Evaluate, 評量行動後對飛行安全有何影響？並繼續再注意覺察飛行情境之變化-To evaluate the influence after taking action and continue watching for the changes of flying condition.)

就單發動機繼續起飛之操作過程，其評量重點如下：(The evaluation for the take-off operation with single engine:)

(1) 左發動機之可靠度。(The left engine's reliability.)

(2) 單發動機操作衍生之困難度。(The difficulty for single engine operation.)

(3) 緊急程序的額外負擔。(The extra burden for emergency procedure.)

(1) **在此種放棄起飛的飛行情境中，您覺得 DESIDE「飛行決策訓練」之「風險評估」的效率如何？**（效率很高 9，尚可接受 5，效率很低 1，請圈選一個數字）

9 8 7 6 5 4 3 2 1

In this scenario, what do you think about the effectivness of DESIDE for situation assessment?

(Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

(2) 在此種放棄起飛的飛行情境中，您覺得 DESIDE「飛行決策訓練」之「危機管理」的效率如何？（效率很高 9，尚可接受 5，效率很低 1，請圈選一個數字）

9 8 7 6 5 4 3 2 1

In this scenario, what do you think about the effectiveness of DESIDE for risk management?

(Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

(3) 在此種放棄起飛的情境中，您覺得 DESIDE「飛行決策訓練」之「時間管理」的效率如何（能否即時應變）？（效率很高 9，尚可接受 5，效率很低 1，請圈選一個數字）

9 8 7 6 5 4 3 2 1

In this scenario, what do you think about the effectivness of DESIDE for response time?

(Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

(4) 在此種飛行情境中，您覺得 DESIDE「飛行決策訓練」之「可行性」如何？（可行性很高 9，尚可接受 5，可行性很低 1，請圈選一個數字）

9 8 7 6 5 4 3 2 1

In this scenario, what do you think about the overall applicability of DESIDE?

(Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

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狀況：雲中編隊失散處置(wingman is making the decision when leader is lost in cloud)

一、狀況：

少校分隊長駕 F–5E00 號機任佳冬對地炸射 4 機領隊，1322 時自台南基地起飛，1337 時高度 1500 呎保持左梯隊實施衝場（東航線），因能見度影響未能對正靶場，即向左轉向三邊，準備重新加入衝場，於二邊轉三邊時進雲，4 號機位於最左側位置，因雲層影響，於轉彎中迷失長機？ (A Lieutenant pilot flying an F-5E (No. 4) was led by a major pilot (No. 1) of four F-5E formation planning to go to a range for bombing drill. Because of low visibility, they held the attitude at 1500 ft and joined the eastern pattern of bomb-site with a left echelon formation. During the phase encompassing the left turn to the downwind leg to rejoin the pattern, the formation was in dark cloud and the No.4 located on the left end of the formation lost sight of leader.)

二、問題：

請問貴官為當時 4 號機應如何處置？ (What would you do if you were the No.4?)

（請做完後面五頁之後，再填寫此處）

三、針對「雲中編隊失散之處置」的狀況

(1) SHOR, (2) PASS, (3) FOR-DEC, (4) SOAR, (5) DESIDE

此五種「飛行決策」訓練方式，您認爲哪一種是最佳之訓練方式？理由爲何？

(Which ADM mnemonic is the best approach for this situation? And Why?)

SHOR「飛行決策訓練」

(S) **刺激 (Stimuli,** 指飛行員感受到外在環境之變化-Pilot perceives surroundings change.)

(1) 無法看到三號機，編隊失去參考依據。(No. 3 was invisible resulted in losing reference for formation.)

(2) 必須與編隊採取安全間隔。(The safe distance was required.)

(H) **假設 (Hypotheses,** 針對新訊息(刺激)提假設，例如是否有飛安顧慮？-Hypotheses for new information (stimulation), for example, “Is anything dangerous?”)

雲中梯隊右轉彎失散。(In dense cloud any wingman in echelon formation lost during the operation of right turn.)

(O) **選擇 (Options,** 現在最重要的是做什麼？該如何做？-What thing would be the first priority to do now? How to do it?)

(1) 採取安全隔離。(Maintain safe separation.)

(2) 進入儀器飛行後，依外圍雲中失散處置程序。(Flying with instruments and following the standard operation procedure of (getting) lost inside clouds.)

(3) 依據佳冬靶場地形位置做處置參考。(Landforms of range can be reference for emergency operation.)

(R) **行動反應 (Response,** 採取行動，做什麼？如何做？何時做？到哪裡？...-To take action. What to do? How to do? When to do? Where to go?...)

(1) 呼叫迷失長機。(Calling out lost.)

(2) 依外圈雲中失散處置程序執行並報告企圖後操作。(To follow the standard operation procedure of getting lost within clouds and report one’s intention to the leader.)

(3) 配合長機企圖雲上或雲下目視集合。(To assemble with leader above or under clouds.)

(1) 在此種放棄起飛的飛行情境中，您覺得 SHOR「飛行決策訓練」之「風險評估」的效率如何？（效率很高 9，尚可接受 5，效率很低 1，請圈選一個數字）

9　8　7　6　5　4　3　2　1

In this scenario, what do you think about the effectivness of SHOR for situation assessment? (Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

(2) 在此種放棄起飛的飛行情境中，您覺得 SHOR「飛行決策訓練」之「危機管理」的效率如何？（效率很高 9，尚可接受 5，效率很低 1，請圈選一個數字）

9　8　7　6　5　4　3　2　1

In this scenario, what do you think about the effectiveness of SHOR for risk management? (Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

(3) 在此種放棄起飛的情境中，您覺得 SHOR「飛行決策訓練」之「時間管理」的效率如何（能否即時應變）？（效率很高 9，尚可接受 5，效率很低 1，請圈選一個數字）

9 8 7 6 5 4 3 2 1

In this scenario, what do you think about the effectivness of SHOR for response time?
(Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

(4) 在此種飛行情境中，您覺得 SHOR「飛行決策訓練」之「可行性」如何？（可行性很高 9，尚可接受 5，可行性很低 1，請圈選一個數字）

9 8 7 6 5 4 3 2 1

In this scenario, what do you think about the overall applicability of SHOR?
(Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

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PASS「飛行決策訓練」

(P) 確認問題 (Problem identification, 辨明目前所處的環境及問題所在-To identify surroundings and problems at present.)

雲中左梯隊右轉彎迷失長機。(Losing leader because of turning right in a left echelon formation inside clouds.)

(A) 取得訊息 (Acquire information, 蒐集與問題有關之訊息-To collect information concerning problems.)

(1) 梯隊右轉、外圈。(Echelon formation turning right and located on outer loop.)

(2) 航向 090 轉至 180 之間迷失長機。(Losing leader when turning from heading 090 to 180.)

(3) 090 方位有一萬呎以上的山脈。(There are mountains higher than 10,000 ft which located on bearing 090.)

(4) 長機航向 180 改平。(Leader leveled off at heading 180.)

(S) 檢驗策略 (Survey strategy, 檢驗解決問題之相關策略之優點與缺點- To survey the strength and weakness of strategies for solving problems.)

(1) 若依循外圈雲中失散處置程序執行，將有接近中央山脈，甚至撞山可能。(If a pilot followed the process to deal with losing inside clouds, it could approach Central Mountains and even strike mountains.)

(2) 進入儀器飛行後，立即改平飛，以避免空間迷向。(After operated with instrument flight, pilot had to level off immediately in order to avoid spatial disorientation.)

(3) 必須依據佳冬靶場地形位置做處置參考，以避開 090 方位之中央山脈。(It was required to follow landforms of the range in order to evade Central Mountains on bearing 090.)

(S) 選擇策略 (Select strategy, 選擇最佳策略並執行- To choose the most proper strategy and take action.)

(1) 執行儀器飛行，保持飛機姿態後改平。(With instrument flight to maintain aircraft's attitude and then level off.)

(2) 呼叫迷失長機並報告企圖後操作(加油門向右爬升至雲上以避開中央山脈、航向 180 改平，目視長機後集合)。(To call out "Lost", report intention and operate aircraft-Push the throttle, climb and turn right until leaving the top of clouds for evading Central Mountains, level off at heading 180 and assemble with Leader by visual flight.)

(3) 配合長機雲上或雲下目視集合。(To assemble with Leader above or under clouds by visual flight.)

(1) 在此種放棄起飛的飛行情境中，您覺得 PASS「飛行決策訓練」之「風險評估」的效率如何？（效率很高 9，尚可接受 5，效率很低 1，請圈選一個數字）

9 8 7 6 5 4 3 2 1

In this scenario, what do you think about the effectivness of PASS for situation assessment?

(Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

(2) 在此種放棄起飛的飛行情境中，您覺得 PASS 「飛行決策訓練」之「危機管理」的效率如何？（效率很高 9，尚可接受 5，效率很低 1，請圈選一個數字）

9 8 7 6 5 4 3 2 1

In this scenario, what do you think about the effectiveness of PASS for risk management?

(Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

(3) 在此種放棄起飛的情境中，您覺得 PASS 「飛行決策訓練」之「時間管理」的效率如何（能否即時應變）？（效率很高9，尚可接受5，效率很低1，請圈選一個數字）

9 8 7 6 5 4 3 2 1

In this scenario, what do you think about the effectivness of PASS for response time?

(Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

(4) 在此種飛行情境中，您覺得 PASS「飛行決策訓練」之「可行性」如何？
（可行性很高 9，尚可接受 5，可行性很低 1，請圈選一個數字）

9 8 7 6 5 4 3 2 1

In this scenario, what do you think about the overall applicability of PASS?

(Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

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FOR-DEC「飛行決策訓練」

(F) 實況 (Facts, 此時此地發生什麼狀況？-What's happening now?)

(1) 左梯隊外圈位置，二邊右轉三邊進雲。(Left ladder formation at outer loop and in the dark clouds during turning from upwind leg to downwind.)

(2) 雲中迷失長機。(Losing Leader in the dark clouds.)

(3) 高度 1500 呎。(Altitude was 1500 ft.)

(4) 090 有高度 10000 呎以上的中央山脈。(The Central Mountains was on bearing 090 and the altitude was above 10000 ft.)

(O) 選項 (Options, 我有什麼樣的對應策略可選擇？- What strategies can be selected?)

(1) 依循外圈雲中失散處置程序執行。(To follow the procedure which deals with losing Leader inside clouds.)

(2) 進入儀器飛行。(Flying with IFR.)

(3) 航向 180 改平。(To level off at ~~the~~ heading 180.)

(R) 危機與優勢 (Risk & Benefits, 不同策略有何不同的潛在危機與優勢？- Are there any risk and benefits between different strategies?)

(1) 若完全依循外圈雲中編隊失散處置程序，恐有撞機之危險。(If a pilot followed the procedure whitch deals with losing inside clouds, it could collide with the Leader.)

(2) 若不進入儀器飛行，而試圖雲中繼續搜索長機，將有導致空間迷向之危險。(If a pilot didn't operate with IFR and tried to find the Leader in the dark clouds that would result in the danger of spatial disorientation.)

(3) 依據佳冬靶場地形位置做處置參考有其必要，因爲 090 方位爲標高 10000 呎以上的山脈，是飛安危害因素。(It was required to follow landforms of the range because of Central Mountains, 10000 ft above, located on bearing 090 that was harmful to flight safety.)

(4) 航向 180 爲避免撞山之最佳策略。(To maintain heading 180 was the best strategy to avoid striking mountains.)

(D) 決心 (Decision, 選定一最佳之策略- To select the best strategy.)

(1) 執行外圈雲中失散處置程序。(To follow the standard operation procedure about outer loop formation which lost Leader inside the dark clouds.)

(2) 進入儀器飛行避免空間迷向。(After operated with instrument flight, pilot had to avoid spatial disorientation.)

(3) 航向 180 避免撞山。(To maintain heading 180 for avoiding striking mountains.)

(D) 執行 (Execution, 執行此最佳策略並注意何時做？做什麼？如何做？-To execute this strategy and pay attention for when, what and how to do it.)

(1) 呼叫迷失長機並報告企圖後操作。(Operate the emergency procedure after calling out "Lost" and reporting intention.)

(2) 隨時注意與左側山脈之安全間隔。(To pay attention to the safe separation intervals with mountains located on the left side.)

(3) 配合長機雲上或雲下目視集合。(To assemble with Leader on the top of clouds or under clouds.)

(C) 檢驗 (Check, 檢驗每個動作執行後對飛行安全所造成之影響- To check if each operation influences the flight safety.)

(1) 檢視目前與山脈的相關位置。(To identify the related position between aircraft and mountains.)

(2) 報告長機目前位置以利其搜尋與重新集合並避免撞機。(To report aircraft's position to Leader was not only for searching and assembling easily, but also for avoiding colliding with each other.)

(3) 隨時以狀態儀檢驗有無空間迷向情況。(Using attitude gauge to diagnosis spatial disorientation all the time.)

(4) 詢問長機位置、航向與高度做爲集合參考。(To inquire the information about Leader's position, heading and altitude for assembling.)

(1) **在此種放棄起飛的飛行情境中，您覺得 FOR-DEC 「飛行決策訓練」之「風險評估」的效率如何？（效率很高 9，尚可接受 5，效率很低 1，請圈選一個數字）**

9 8 7 6 5 4 3 2 1

In this scenario, what do you think about the effectivness of FOR-DEC for situation assessment? (Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

(2) **在此種放棄起飛的飛行情境中，您覺得 FOR-DEC 「飛行決策訓練」之「危機管理」的效率如何？（效率很高 9，尚可接受 5，效率很低 1，請圈選一個數字）**

9 8 7 6 5 4 3 2 1

In this scenario, what do you think about the effectiveness of FOR-DEC for risk management? (Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

(3) **在此種放棄起飛的情境中，您覺得 FOR-DEC 「飛行決策訓練」之「時間管理」的效率如何（能否即時應變）？（效率很高 9，尚可接受 5，效率很低 1，請圈選一個數字）**

9 8 7 6 5 4 3 2 1

In this scenario, what do you think about the effectivness of FOR-DEC for response time? (Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

(4) **在此種飛行情境中，您覺得 FOR-DEC「飛行決策訓練」之「可行性」如何？（可行性很高 9，尚可接受 5，可行性很低 1，請圈選一個數字）**

9 8 7 6 5 4 3 2 1

In this scenario, what do you think about the overall applicability of FOR-DEC? (Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

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SOAR「飛行決策訓練」

(S) 情境 (Situation, 目前飛機、飛行環境、與飛行員之狀況如何？-What is the situation of the aircraft, surroundings and pilots?)

(1) 左梯隊外圈位置，二邊右轉三邊進雲。(Left echelon formation at outer loop and in the dark clouds during turning from upwind leg to downwind.)

(2) 雲中迷失長機。(Losing Leader in the dark clouds.)

(3) 090 方位有 10000 呎以上的山脈。(The mountain area was on bearing 090 and the altitude was above 10000 ft.)

(4) 目前高度 1500 呎。(Aircraft's altitude at that time was 1500 ft.)

(O) 選項 (Options, 評估可選擇之策略有哪些？執行後會有哪些後果？選擇最佳策略-To evaluate feasible strategies, to figure out the possible results after executeing and to select the best strategy.)

(1) 若未依循外圈雲中失散處置程序，恐有接近山脈及撞機危險。(If pilot didn't follow the procedure of dealing with losing inside clouds, it could approach mountains and collide with Leader.)

(2) 進入儀器飛行後，立即改平飛，以避免空間迷向。(After operated with instrument flight, pilot had to level off immediately in order to avoid spatial disorientation.)

(3) 航向 180 避免撞山。(To maintain heading 180 for avoiding striking mountains.)

(A) 行動 (Act, 執行所選擇之最佳策略，並注意對飛行情境所造成之變化-To execute the best strategy and watch out surroundings' change.)

(1) 呼叫迷失長機並報告企圖後執行外圈雲中失散處置程序。(To follow the standard operation procedure for outer loop formation when losing Leader inside the dark clouds after calling out "Lost" and reporting intention.)

(2) 進入儀器飛行以避免空間迷向。(After operated with instrument flight, pilot had to avoid spatial disorientation.)

(3) 配合長機至雲上或雲下目視集合。(To assemble with Leader on the top of clouds or under clouds.)

(R) 重複評估情境與選項 (Repeat, 重複評估飛機與飛行環境，選擇並執行最佳策略 -Repeat evaluation for aircraft, flight environments and pilots' condition; select and execute the best strategy.)

(1) 報告長機目前位置以利其搜尋與重新集合。(To report aircraft's position to Leader for searching and assembling easily.)

(2) 進入儀器飛行確認航向 180。(To operate with instrument flight and identify the heading of 180.)

(3) 確認長機位置、航向與高度做爲集合參考。(To identify the information about Leader's position, heading and altitude for assembling reference.)

(1) 在此種放棄起飛的飛行情境中，您覺得 SOAR「飛行決策訓練」之「風險評估」的效率如何？（效率很高 9，尚可接受 5，效率很低 1，請圈選一個數字）

9 8 7 6 5 4 3 2 1

In this scenario, what do you think about the effectivness of SOAR for situation assessment?

(Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

(2) 在此種放棄起飛的飛行情境中，您覺得 SOAR「飛行決策訓練」之「危機管理」的效率如何？（效率很高 9，尚可接受 5，效率很低 1，請圈選一個數字）

9 8 7 6 5 4 3 2 1

In this scenario, what do you think about the effectiveness of SOAR for risk management?

(Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

(3) 在此種放棄起飛的情境中，您覺得SOAR「飛行決策訓練」之「時間管理」的效率如何（能否即時應變）？（效率很高9，尚可接受5，效率很低1，請圈選一個數字）

9 8 7 6 5 4 3 2 1

In this scenario, what do you think about the effectivness of SOAR for response time?

(Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

(4) 在此種飛行情境中，您覺得 SOAR「飛行決策訓練」之「可行性」如何？
（可行性很高 9，尚可接受 5，可行性很低 1，請圈選一個數字）

9 8 7 6 5 4 3 2 1

In this scenario, what do you think about the overall applicability of SOAR?

(Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

****

DESIDE「飛行決策訓練」

(D) 察覺 (Detect, 覺察飛行環境與飛機狀況是否有異常-To detect if any unusual condition about surroundings and aircraft.)

(1) 雲中迷失長機，若不立即處置恐有撞機與空間迷向之虞。
(2) 若不採取正確處置，恐有撞山之虞。

(D) 估計 (Estimate, 根據所覺察之飛行狀況，評估對飛安之影響-To evaluate the influence on flight safety based on flying condition.)

(1) 告知長機採取雲中失散處置企圖。
(2) 立即進入儀器飛行改平飛，以避免空間迷向與雲中擦撞。
(3) 航向 180 避免撞山。

(S) 設立安全目標 (Set Safety Objectives, 尋找是否有較好的解決策略？-Are there any more proper strategies?)

(1) 採雲上目視集合爲最大安全模式。
(2) 依據靶場地形彈性運用雲中失散處置程序，以避免撞山危險。

(I) 確認 (Identify, 是否有足夠的時間收集更多訊息，並評估行動策略-Is time enough to collect more information and evaluate strategies.)

(1) 090 方位爲一萬呎以上的中央山脈，要隨時確認所在位置。
(2) 確認處置方案(雲中失散處置程序)。

(D) 行動 (Do, 執行最佳行動策略-Take action.)

(1) 無線電呼叫迷失長機
(2) 執行雲中失散處置程序
(3) 進入儀器飛行。
(4) 依據佳冬靶場地形航向 180 避免撞山。
(5) 配合長機雲上或雲下目視集合。

(E) 評量 (Evaluate, 評量行動後對飛行安全有何影響？並繼續再注意覺察飛行情境之變化-To evaluate the influence after taking action and continue watching for the changes of flying condition.)

(1) 隨時檢視目前與山脈的相關位置。
(2) 在出雲以前，隨時以狀態儀檢驗有無空間迷向情況。
(3) 報告長機目前位置以利其搜尋與重新集合。
(4) 評估長機位置、航向與高度做爲集合參考。

(1) **在此種放棄起飛的飛行情境中，您覺得 DESIDE「飛行決策訓練」之「風險評估」的效率如何？**（效率很高 9，尚可接受 5，效率很低 1，請圈選一個數字）

9　8　7　6　5　4　3　2　1

In this scenario, what do you think about the effectivness of DESIDE for situation assessment?
(Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

(2) 在此種放棄起飛的飛行情境中，您覺得 DESIDE「飛行決策訓練」之「危機管理」的效率如何？（效率很高 9，尚可接受 5，效率很低 1，請圈選一個數字）

9　8　7　6　5　4　3　2　1

In this scenario, what do you think about the effectiveness of DESIDE for risk management?

(Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

(3) 在此種放棄起飛的情境中，您覺得DESIDE「飛行決策訓練」之「時間管理」的效率如何（能否即時應變）？（效率很高9，尚可接受5，效率很低1，請圈選一個數字）

9　8　7　6　5　4　3　2　1

In this scenario, what do you think about the effectivness of DESIDE for response time?

(Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

(4) 在此種飛行情境中，您覺得 DESIDE「飛行決策訓練」之「可行性」如何？（可行性很高 9，尚可接受 5，可行性很低 1，請圈選一個數字）

9　8　7　6　5　4　3　2　1

In this scenario, what do you think about the overall applicability of DESIDE?

(Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

****

狀況：接敵過程未目視目標機處置(decision-making with no ‘tally-ho!’ during a practice engagement)

一、狀況：

少校分隊長率 F-5E×4 **實施** AI / ACM **課目，於** 1100 **起飛至** R-8 **空域，先由** 1、2 **號機擔任攔截機高度** 20M**，**3、4 **號機任目標機高度** 22M**，於第** 3 **次航線由** 2 **號機任前位機，長機保持戰鬥僚機位置，**3、4 **號機保持防禦隊形實施** 1 **對** 2 **演練，在戰管引導至** 6 **浬時，**2 **號目視** 3、4 **號機，即開始佔位接敵，**3、4 **號機亦實施兩機防禦操作，於第一次對頭通過再回頭時，**3、4 **號機呼叫未發現** 1、2 **號機，**2 **號機呼叫目視一架在** 12 **點半同高度，對頭接近中？** (A pilot with the rank of Major was the leader of a four F-5E formation in airspace for air intercept drill. At the third pass the No. 2 change position as the leader and the Major held a tactical position in an offense unit. No. 3 and No.4 were operating as another unit to practice defense maneuvers in line abreast. When the interceptor controller on the radar site guided them to the engagement phase, No.3 and No.4 called out “No Joy for 1 and 2” and at the same time No.2 also called out “one opposing target approaching on 12:30 o’clock with same altitude”.)

二、問題：

請問貴官為長機應如何處置？ (What would you do if you were the leader?)

（**請做完後面五頁之後，再填寫此處**- Please read the questions on the following 5-pages first, and then answer the questions here）

三、針對針對「**接敵過程未目視目標機之處置**」的狀況

(1) SHOR, (2) PASS, (3) FOR-DEC, (4) SOAR, (5) DESIDE

此五種「飛行決策」訓練方式，您認爲哪一種是最佳之訓練方式？理由爲何？

(Which ADM mnemonic is the best approach for this situation? And Why?)

SHOR「飛行決策訓練」

(S) 刺激 (<u>S</u>timuli, 指飛行員感受到外在環境之變化-A pilot perceives surroundings change.)

(1) 由無線電得知三、四號機未能目視一、二號機。(By using the radio to know that No. 3 and No. 4 could not see the leader and NO.2.)

(2) 由無線電得知二號機目視一架在十二點半方位同高度，對頭接近中。(By using the radio to know that No.2 saw one opposing target approaching on 12:30 o'clock with same altitude.)

(3) 長機未能目視三、四號機。(Leader could not see No. 3 and 4.)

(4) 有撞機之危險。(It would have a risk for colliding with another aircraft.)

(H) 假設 (<u>H</u>ypotheses, 針對新訊息(刺激)提假設，例如是否有安全顧慮？-Hypotheses for new information (stimulation), for example, "Is anything dangerous?")

(1) 除二號機目視一架有危害，其餘均未能目視彼此。(Except No.2 could see one endangering aircraft, the others couldn't see each other.)

(2) 有嚴重撞機顧慮。(There was a very high risk to collide with another aircrafts.)

(O) 選擇 (<u>O</u>ptions, 現在最重要的是做什麼？該如何做？-What would be the first priority to do now? How to do?)

(1) 下令立即停止訓練，二號機採取高度隔離。(To stop training immediately and No.2 took the separation of altitude.)

(2) 下令各小隊保持進入高度隔離及保持左側。(To have a command that each squad maintain the beginning altitude for safe separation and keep on the left side.)

(3) 要求戰管重新引導攔截。(To ask groud controller re-guide all flights to intercept each other.)

(R) 行動反應 (<u>R</u>esponse, 採取行動，做什麼？如何做？何時做？到哪裡？...-To take action. What to do? How to do? When to do? Where to go?...)

(1) 配合二號機操作採取高度隔離。(To operate in coordination with No.2 and have a altitude separation.)

(2) 無線電指示各小隊採取高度與間隔雙重隔離。(By using the radio to command each squad to start altitude and distance separation.)

(3) 無線電提供各小隊位置，以利搜索及目視對方。(By using the radio to provide each squad's position for searching and seeing each other.)

(4) 請戰管協助確認各小隊位置，並引導集合後再行訓練。(To ask ground controller to identify each squad's position, guide them to assemble and then continue training.)

(1) 在此種放棄起飛的飛行情境中，您覺得 SHOR「飛行決策訓練」之「風險評估」的效率如何？（效率很高 9，尚可接受 5，效率很低 1，請圈選一個數字）

9 8 7 6 5 4 3 2 1

In this scenario, what do you think about the effectivness of SHOR for situation assessment?

(Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

(2) 在此種放棄起飛的飛行情境中，您覺得 SHOR「飛行決策訓練」之「危機管理」的效率如何？（效率很高 9，尚可接受 5，效率很低 1，請圈選一個數字）

9 8 7 6 5 4 3 2 1

In this scenario, what do you think about the effectiveness of SHOR for risk management?

(Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

(3) 在此種放棄起飛的情境中，您覺得 SHOR「飛行決策訓練」之「時間管理」的效率如何（能否即時應變）？（效率很高 9，尚可接受 5，效率很低 1，請圈選一個數字）

9 8 7 6 5 4 3 2 1

In this scenario, what do you think about the effectivness of SHOR for response time?

(Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

(4) 在此種飛行情境中，您覺得 SHOR「飛行決策訓練」之「可行性」如何？（可行性很高 9，尚可接受 5，可行性很低 1，請圈選一個數字）

9 8 7 6 5 4 3 2 1

In this scenario, what do you think about the overall applicability of SHOR?

(Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

****

PASS「飛行決策訓練」

(P) 確認問題 (Problem identification, 辨明目前所處的環境及問題所在-To identify surroundings and problems at present. **)**

(1) 攔截訓練未能目視對方。(During intercept training pilots could not see each other.)

(2) 二號機目視三或四號機在略爲右側、對頭同高度。(No.2 could see No.3 and 4 on his right side who were opposing and approaching with same altitude.)

(3) 有撞機之潛在危險。(There was a potential risk to collide each other.)

(A) 取得訊息 (Acquire information, 蒐集與問題有關之訊息-To collect information concerning problems. **)**

(1) 由無線電得知三、四號機未能目視一、二號機。(By using the radio to know that No. 3 and No. 4 could not see 1 and 2.)

(2) 由無線電得知二號機目視一架在十二點半方位同高度，對頭接近中。(By radio it was known that one target was opposing and approaching on 12:30 ~~o'clock~~ with same altitude.)

(3) 長機未能目視三、四號機。(Leader could not see No.3 and 4.)

(S) 檢驗策略 (Survey strategy, 檢驗解決問題之相關策略之優點與缺點- To survey the strength and weakness of strategies for solving problems. **)**

(1) 下令立即停止訓練並採取高度隔離以避免空中接近，甚至擦撞危險。(Having a command to stop training and start to adopt altitude separation to avoid the danger of approaching, or even collision.)

(2) 各小隊若繼續執行科目又試圖目視搜索，除違反訓練規定，且頻增危安因素 (It was not only to violate training regulation but also to increase risk if each squad continued to oprate flying course.)

(S) 選擇策略 (Select strategy, 選擇最佳策略並執行- To choose the most proper strategy and take action.**)**

(1) 下令立即停止訓練並採取高度隔離。(To command each squad to start altitude separation immediately.)

(2) 下令各小隊採取安全高度隔離及保持左側。(To command each squad to maintain the safe altitude separation and keep on the left side.)

(3) 無線電提供各小隊位置，以利搜索及目視對方。(By using the radio to provide each squad's position for searching and seeing each other.)

(4) 請戰管協助確認各小隊位置，並引導集合後再行訓練。(To ask ground controller to identify each squad's position, guide them to assemble and then continue training.)

(1) 在此種放棄起飛的飛行情境中，您覺得 PASS「飛行決策訓練」之「風險評估」的效率如何？（效率很高 9，尚可接受 5，效率很低 1，請圈選一個數字）

9 8 7 6 5 4 3 2 1

In this scenario, what do you think about the effectivness of PASS for situation assessment?
(Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

(2) 在此種放棄起飛的飛行情境中，您覺得 PASS 「飛行決策訓練」之「危機管理」的效率如何？（效率很高 9，尚可接受 5，效率很低 1，請圈選一個數字）

9 8 7 6 5 4 3 2 1

In this scenario, what do you think about the effectiveness of PASS for risk management?
(Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

(3) 在此種放棄起飛的情境中，您覺得 PASS 「飛行決策訓練」之「時間管理」的效率如何（能否即時應變）？（效率很高9，尚可接受5，效率很低1，請圈選一個數字）

9 8 7 6 5 4 3 2 1

In this scenario, what do you think about the effectivness of PASS for response time?
(Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

(4) 在此種飛行情境中，您覺得 PASS「飛行決策訓練」之「可行性」如何？
（可行性很高 9，尚可接受 5，可行性很低 1，請圈選一個數字）

9 8 7 6 5 4 3 2 1

In this scenario, what do you think about the overall applicability of PASS?
(Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

****

FOR-DEC「飛行決策訓練」

(F) 實況 (Facts, 此時此地發生什麼狀況？-What's happening now?)

(1) 由無線電得知三、四號機未能目視一、二號機。(By using the radio to know that No. 3 and No. 4 could not see 1 and 2.)

(2) 由無線電得知二號機目視一架在十二點半方位同高度，對頭接近中。(By using the radio to know that No.2 saw one opposing target approaching on 12:30 ~~o'clock~~ with same altitude.)

(3) 長機未能目視三、四號機。(Leader could not see No.3 and 4.)

(4) 有撞機之潛在危險。(There was a potential risk to collide each other.)

(O) 選項 (Options, 我有什麼樣的對應策略可選擇？- What strategies can be selected?)

立即停止訓練並採取安全隔離。(Having a command to stop training and start to adopt safe separation)

(R) 危機與優勢 (Risk & Benefits, 不同策略有何不同的潛在危機與優勢？- Have any risk and benefits for different strategies?)

(1) 若不停止訓練並採安全隔離，存在極危險之因素。(It would be extreme dangerous if not stop~~ping~~ training and maintain safe separation.)

(2) 按訓練規定，雙方未目視情況下不可實施接戰訓練。(According to training rule, the engagement training cannot be done if pilots cannot see each other.)

(D) 決心 (Decision, 選定一最佳之策略- To select the best strategy.)

立即停止訓練。(To stop training immediately.)

(E) 執行 (Execution, 執行此最佳策略並注意何時做？做什麼？如何做？-To execute this strategy and watch out for when, what and how to do it.)

(1) 下令各小隊保持進入高度隔離及保持左側。(To command each squad to maintain the beginning altitude for separation and the position on the left side.)

(2) 下令二號機立即採取安全隔離並停止訓練。(To command No.2 to adopt safe separation and stop training.)

(3) 請戰管協助確認各小隊位置，並引導集合後再行訓練。(To ask ground controller to identify each squad's position, guide them to assemble and then continue training.)

(C) 檢驗 (Check, 檢驗每個動作執行後對飛行安全所造成之影響- To check if each operation influences flight the safety.)

(1) 確認二號機按指示立即採取安全隔離並停止訓練。(To make sure that No.2 had followed the command to adopt safe separation and stop training.)

(2) 確認三、四號機航向隔離。(To make sure that No.3 and 4 had adopted heading separation.)

(3) 確認戰管提供各小隊位置協助搜索評估並重新引導攔截。(To make sure that ground controller had identified each squad's position and guided them to assemble for continue training.)

(1) 在此種放棄起飛的飛行情境中，您覺得 FOR-DEC 「飛行決策訓練」之「風險評估」的效率如何？（效率很高 9，尚可接受 5，效率很低 1，請圈選一個數字）

9 8 7 6 5 4 3 2 1

In this scenario, what do you think about the effectivness of FOR-DEC for situation assessment?
(Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

(2) 在此種放棄起飛的飛行情境中，您覺得 FOR-DEC 「飛行決策訓練」之「危機管理」的效率如何？（效率很高 9，尚可接受 5，效率很低 1，請圈選一個數字）

9 8 7 6 5 4 3 2 1

In this scenario, what do you think about the effectiveness of FOR-DEC for risk management?
(Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

(3) 在此種放棄起飛的情境中，您覺得 FOR-DEC 「飛行決策訓練」之「時間管理」的效率如何（能否即時應變）？（效率很高 9，尚可接受 5，效率很低 1，請圈選一個數字）

9 8 7 6 5 4 3 2 1

In this scenario, what do you think about the effectivness of FOR-DEC for response time?
(Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

(4) 在此種飛行情境中，您覺得 FOR-DEC「飛行決策訓練」之「可行性」如何？
（可行性很高 9，尚可接受 5，可行性很低 1，請圈選一個數字）

9 8 7 6 5 4 3 2 1

In this scenario, what do you think about the overall applicability of FOR-DEC?
(Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

****

SOAR「飛行決策訓練」

(S) 情境 (Situation, 目前飛機、飛行環境、與飛行員之狀況如何？-What is the situations of the aircraft, surroundings and pilots?)

(1) 由無線電得知三、四號機未能目視一、二號機。(By using the radio to know that No. 3 and No. 4 could not see 1 and 2.)

(2) 由無線電得知二號機目視一架在十二點半方位同高度，對頭接近中。(By using the radio to know that No.2 saw one opposing target approaching on 12:30 ~~o'clock~~ with same altitude.)

(3) 長機未能目視三、四號機。(Leader could not see No.3 and 4.)

(O) 選項 (Options, 評估可選擇之策略有哪些？執行後會有哪些後果？選擇最佳策略-To evaluate feasible strategies, to figure out the possible results after executeing and to select the best strategy. **)**

採區安全隔離並立即停止訓練爲唯一選項。(It was unique option to start to adopt safe separation and stop training.)

(A) 行動 (Act, 執行所選擇之最佳策略，並注意對飛行情境所造成之變化-To execute the best strategy and watch out the surroundings' change. **)**

(1) 下令二號機採取安全隔離並立即停止訓練。(To command No.2 to adopt safe separation and stop training.)

(2) 下令各小隊保持進入高度隔離及保持左側。(To command each squad to maintain the beginning altitude for separation and the position on the left side.)

(3) 無線電提供各小隊位置，以利搜索及目視對方。(By radio to provide each squad's position for searching and seeing each other.)

(4) 請戰管協助確認各小隊位置，並重新引導攔截。(To ask ground controller to identify each squad's position, guide them to assemble and then continue training.)

(R) 重複評估情境與選項 (Repeat, 重複評估飛機與飛行環境，選擇並執行最佳策略 -Repeat evaluation for aircraft, flight surroundings and pilots' condition; select and execute the best strategy. **)**

(1) 以各小隊所報位置相互搜索評量操作方式。(To search each other and evaluate operation methods based on the position reported by each squad.)

(2) 以戰管提供各小隊位置協助搜索評估。(To search each other based on the position information provided by radar site controller.)

(3) 以能目視對方爲接戰訓練基本要求。(Being able to see each other is the basic requirement for engagement training.)

(1) 在此種放棄起飛的飛行情境中，您覺得 SOAR「飛行決策訓練」之「風險評估」的效率如何？（效率很高 9，尚可接受 5，效率很低 1，請圈選一個數字）

9 8 7 6 5 4 3 2 1

In this scenario, what do you think about the effectivness of SOAR for situation assessment? (Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

(2) 在此種放棄起飛的飛行情境中，您覺得 SOAR「飛行決策訓練」之「危機管理」的效率如何？（效率很高 9，尚可接受 5，效率很低 1，請圈選一個數字）

9 8 7 6 5 4 3 2 1

In this scenario, what do you think about the effectiveness of SOAR for risk management? (Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

(3) 在此種放棄起飛的情境中，您覺得 SOAR「飛行決策訓練」之「時間管理」的效率如何（能否即時應變）？（效率很高 9，尚可接受 5，效率很低 1，請圈選一個數字）

9 8 7 6 5 4 3 2 1

In this scenario, what do you think about the effectivness of SOAR for response time? (Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

(4) 在此種飛行情境中，您覺得 SOAR「飛行決策訓練」之「可行性」如何？（可行性很高 9，尚可接受 5，可行性很低 1，請圈選一個數字）

9 8 7 6 5 4 3 2 1

In this scenario, what do you think about the overall applicability of SOAR? (Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

****

DESIDE「飛行決策訓練」

(D) 察覺 (Detect, 覺察飛行環境與飛機狀況是否有異常-To detect if any unusual condition about the surroundings and the aircraft. **)**

(1) 由無線電得知三、四號機未能目視一、二號機。(By using the radio to know that No. 3 and No. 4 could not see the leader and NO.2.)

(2) 由無線電得知二號機目視一架在十二點半方位同高度，對頭接近中。(By using the radio to know that No.2 saw one opposing target approaching on 12:30 ~~o'clock~~ with same altitude.)

(3) 長機未能目視三、四號機。(Leader could not see No.3 and NO.4.)

(4) 若不立即採取安全隔離，恐有接近或撞機危險。(It could have the risk of approaching or collision if not adopting safe separation immediately.)

(E) 估計 (Estimate, 根據所覺察之飛行狀況，評估對飛安之影響-To evaluate the influence on the flight safety based on flying condition.**)**

(1) 研判各小隊均有盲點。(It was deduced that both squads had blind spot.)

(2) 據無線電研判二號機與三或四號機在略爲右側對頭同高度。(By using the radio to deduce that No.2 had same altitude as No.3 or NO.4 and were opposing each other on slightly right side.)

(3) 此狀況有安全顧慮，絕對不可訓練。(It was absolutely unable to continue training because the situation had high risk.)

(S) 設立安全目標 (Set Safety Objectives, 尋找是否有較好的解決策略？-Has any more proper strategy?**)**

採取安全隔離立即停止訓練，重新集合後再訓練。(To adopt safe separation, stop training immediately, assemble together and then continue training.)

(I) 確認 (Identify, 是否有足夠的時間收集更多訊息，並評估行動策略-Is time enough to collect more information and evaluate strategies?**)**

確認二號機領知長機指示並執行安全隔離。(To make sure No.2 followed Leader's command and carry out the safe separation.)

(D) 行動 (Do, 執行最佳行動策略-Take action. **)**

(1) 下令二號機採安全隔離並立即停止訓練。(To command No.2 to adopt safe separation and stop training.)

(2) 下令各小隊保持進入高度隔離及保持左側。(To command each squad to maintain the beginning altitude for separation and the position on the left side.)

(3) 無線電提供各小隊位置，以利搜索及目視對方。(By using the radio to provide each squad's position for searching and seeing each other.)

(4) 請戰管協助確認各小隊位置，並引導集合後再行訓練。(To ask ground controller to identify each squad's position, guide them to assemble and then continue training.)

(E) 評量 (Evaluate, 評量行動後對飛行安全有何影響？並繼續再注意覺察飛行情境之變化-To evaluate the influence after taking action and continue watching for the changes of flying condition. **)**

立即停止訓練後，各小隊必須執行以下各點，並隨時評量有無危害飛安。(After stopping training, it was required that each squad carried out the following items and evaluated if there were harmful to the flight safety all the time.)

(1) 以各小隊所報位置相互搜索評量操作方式。(To search each other and evaluate operation methods based on the position information reported by each squad.)

(2) 以戰管提供各小隊位置協助搜索評估。(To search each other based on the position information provided by radar site controller.)

(3) 各小隊遵守律定空層，以維安全。(Each squad obeyed the assigned altitude for flight safety.)

(4) 有無其他危安因素。(To evalute all the time if any harmful factor was occured.)

(1) **在此種放棄起飛的飛行情境中，您覺得 DESIDE「飛行決策訓練」之「風險評估」的效率如何？**（效率很高 9，尚可接受 5，效率很低 1，請圈選一個數字）

9 8 7 6 5 4 3 2 1

In this scenario, what do you think about the effectivness of DESIDE for situation assessment?

(Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

(2) **在此種放棄起飛的飛行情境中，您覺得 DESIDE「飛行決策訓練」之「危機管理」的效率如何？**（效率很高 9，尚可接受 5，效率很低 1，請圈選一個數字）

9 8 7 6 5 4 3 2 1

In this scenario, what do you think about the effectiveness of DESIDE for risk management?

(Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

(3) **在此種放棄起飛的情境中，您覺得DESIDE「飛行決策訓練」之「時間管理」的效率如何（能否即時應變）？**（效率很高9，尚可接受5，效率很低1，請圈選一個數字）

9 8 7 6 5 4 3 2 1

In this scenario, what do you think about the effectivness of DESIDE for response time?

(Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

(4) **在此種飛行情境中，您覺得 DESIDE「飛行決策訓練」之「可行性」如何？（可行性很高 9，尚可接受 5，可行性很低 1，請圈選一個數字）**

9 8 7 6 5 4 3 2 1

In this scenario, what do you think about the overall applicability of DESIDE?

(Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

****

狀況：儀飛進場無法落地且油量在 BINGO 邊緣之處置(Unable to land during instrument flight in a bingo fuel situation.)

一、狀況

少校分隊長駕 F–5E 00 **號機任** BFM **課目之長機，中尉飛行官駕** F–5E 00 **號機任僚機，**0745 **時自台東起飛至** F **空域實施訓練，**0830 **時訓練完畢返航，當時** ACC **提示本場天氣漸趨轉劣，能見度** 1 **哩雲幕降至** 600 **呎，領隊詢問備降場天氣得知；台南為** 1 ½**哩，雲幕** 1000 **呎；嘉義及花蓮均為** 5 **哩，雲幕** 3000 **呎，以南天氣亦均為目視天氣，遂請求** ACC **引導至** Z1 **點實施** GCA **進場，下降至** 4000 **呎開始進雲，五邊** 10 **浬由** GCA **引導至** 1 **哩始出雲目視跑道，唯與跑道偏角較大，乃指示僚機單機落地長機重飛，唯相隔** 5 **秒，聽到僚呼叫重飛，當時餘油** 1300 **磅。**(After basic fighting maneuver drill in the airspace, one F-5E formation requested Air Control Center to guide them to Z-1 Intense Point for Ground Control Approach pattern because of bad weather. From 4000 ft. they began flying in dark cloud and were guided by GCA. At 1 mile from runway they were out of cloud but the angle between the flight line and the runway-was too great to land. Hence leader directed only No. 2 to land and he decided to go-around, but 5 seconds later No.2 also called out '2 go-around with 1300 lb gasoline only'.)

二、問題：

請問貴官為當時之長機如何處置？ (What would you do if you were the leader?)

* * *

（**請做完後面五頁之後，再填寫此處**- Please read the questions on the following 5-pages first, and then answer the questions here ）

三、針對「**儀飛進場無法落地且油量在** BINGO **邊緣之處置**」的狀況

(1) SHOR, (2) PASS, (3) FOR-DEC, (4) SOAR, (5) DESIDE

此五種「飛行決策」訓練方式，您認爲哪一種是最佳之訓練方式？理由爲何？

(Which ADM mnemonic is the best approach for this situation? And Why?)

SHOR「飛行決策訓練」

(S) 刺激 (**S**timuli, 指飛行員感受到外在環境之變化-A pilot perceives surroundings change.)

(1) 本場天氣轉劣。(Home base weather was worse.)

(2) 五邊一哩 600 呎出雲目視跑道，但偏角過大。(One mile on final with 600 ft altitude from runway the formation was out of cloud but the angle between the flight line and the runway was too great to land.)

(3) 僚機單機落地不成改重飛。(No.2 could not land and requested go-arround.)

(4) 僚機餘油 1300 磅。(No.2 had remaining gasoline of 1300 lb.)

(H) 假設 (**H**ypotheses, 針對新訊息(刺激)提假設，例如是否有安全顧慮？-Hypotheses for new information (stimulation), for example, "Is anything dangerous?")

(1) 預計本場天氣不適合落地。(It was predicted that home base weather was improper for landing.)

(2) 僚機操作能力不足。(No.2 was inexperienced in operation.)

(3) 管制官引導經驗不足。(Ground controller was inexperienced.)

(O) 選擇 (**O**ptions, 現在最重要的是做什麼？該如何做？-What thing is first priority to do now? How to do?)

(1) 轉降外場。(To land the other base.)

(2) 重新加入 GCA 航線。(To re-join GCA pattern.)

(R) 行動反應 (**R**esponse, 採取行動，做什麼？如何做？何時做？到哪裡？...-To take action. What to do? How to do? When to do? Where to go?...)

轉降花蓮機場爲最安全選擇。(It was the safest option to land YU base.)

(1) **在此種放棄起飛的飛行情境中，您覺得 SHOR「飛行決策訓練」之「風險評估」的效率如何？**（效率很高 9，尚可接受 5，效率很低 1，請圈選一個數字）

9 8 7 6 5 4 3 2 1

In this scenario, what do you think about the effectivness of SHOR for situation assessment? (Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

(2) **在此種放棄起飛的飛行情境中，您覺得 SHOR「飛行決策訓練」之「危機管理」的效率如何？**（效率很高 9，尚可接受 5，效率很低 1，請圈選一個數字）

9 8 7 6 5 4 3 2 1

In this scenario, what do you think about the effectiveness of SHOR for risk management? (Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

(3) 在此種放棄起飛的情境中，您覺得 SHOR「飛行決策訓練」之「時間管理」的效率如何（能否即時應變）？（效率很高 9，尚可接受 5，效率很低 1，請圈選一個數字）

9 8 7 6 5 4 3 2 1

In this scenario, what do you think about the effectivness of SHOR for response time?

(Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

(4) 在此種飛行情境中，您覺得 SHOR「飛行決策訓練」之「可行性」如何？（可行性很高 9，尚可接受 5，可行性很低 1，請圈選一個數字）

9 8 7 6 5 4 3 2 1

In this scenario, what do you think about the overall applicability of SHOR?

(Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

****

PASS「飛行決策訓練」

(P) 確認問題 (Problem identification, 辨明目前所處的環境及問題所在-To identify surroundings and problems at present. **)**

(1) 本場天氣無法目視起降，必須仰賴 GCA 引導。(The home base weather did not allow taking-off and landing with visual flight and had to rely on GCA.)

(2) 僚機無法落地，呼叫重飛。(No.2 could not land so called out "Go Around".)

(3) 僚機油量餘 1300 磅，在此情況下屬低油量。(No.2's remaining gasoline, 1300 lb, was low amount of fuel.)

(4) 二機分開無法目視。(Leader and No.2 were separated and couldn't see each other.)

(A) 取得訊息 (Acquire information, 蒐集與問題有關之訊息-To collect information concerning problems. **)**

(1) 本場不適合再次試行落地。(Home base was improper for trying to land again.)

(2) 備降場天氣，嘉義與花蓮均為五哩，雲幕 3000 呎。(Spare bases, KU and YU, were 5-mile visibility and 3000 ft ceiling.)

(3) 衡量剩餘油量與僚機能力，以花蓮作為備降場。(To evaluate the remaining gasoline and No.2's flight ability, YU would be spare base for landing.)

(S) 檢驗策略 (Survey strategy, 檢驗解決問題之相關策略之優點與缺點- To survey the strength and weakness of strategies for solving problems.**)**

轉降花蓮機場。(Go to land YU base.)

(S) 選擇策略 (Select strategy, 選擇最佳策略並執行- To choose the most proper strategy and take action.**)**

(1) 呼叫分二批引導轉降花蓮。(To call out "Request to land at YU airbase in 2 elements.")

(2) 請台東進場台優先引導定向花蓮機場，並告知花蓮進場台低油量訊息並優先引導僚機進場。(To ask ZN Approach to guide to YU with the first priority and inform YU those who had low fuel and allowed landing firstly.)

(3) 指示僚機太康調向花蓮基地台並油門軍用以 300 浬爬升至雲上。(To indicate No.2 adjust TACAN frequency to YU and climb to above clouds with 300 knots at military throttle.)

(1) **在此種放棄起飛的飛行情境中，您覺得 PASS「飛行決策訓練」之「風險評估」的效率如何？**（**效率很高 9，尚可接受 5，效率很低 1，請圈選一個數字**）

9　8　7　6　5　4　3　2　1

In this scenario, what do you think about the effectivness of PASS for situation assessment?
(Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

(2) 在此種放棄起飛的飛行情境中，您覺得 PASS 「飛行決策訓練」之「危機管理」的效率如何？（效率很高 9，尚可接受 5，效率很低 1，請圈選一個數字）

9 8 7 6 5 4 3 2 1

In this scenario, what do you think about the effectiveness of PASS for risk management?

(Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

(3) 在此種放棄起飛的情境中，您覺得 PASS 「飛行決策訓練」之「時間管理」的效率如何（能否即時應變）？（效率很高 9，尚可接受 5，效率很低 1，請圈選一個數字）

9 8 7 6 5 4 3 2 1

In this scenario, what do you think about the effectivness of PASS for response time?

(Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

(4) 在此種飛行情境中，您覺得 PASS「飛行決策訓練」之「可行性」如何？（可行性很高 9，尚可接受 5，可行性很低 1，請圈選一個數字）

9 8 7 6 5 4 3 2 1

In this scenario, what do you think about the overall applicability of PASS?

(Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

****

FOR-DEC「飛行決策訓練」

(F) 實況 (Facts, 此時此地發生什麼狀況？-What's happening now?)

(1) 本場天氣轉劣。(Home base weather was getting worse.)

(2) 五邊一哩 600 呎出雲目視跑道，但偏角過大。(One mile on final with 600 ft altitude ~~from runway the formation~~ was out of cloud in order to take visual of the runway but the angle between the flight line and the runway was too great to land.)

(3) 僚機單機落地不成改重飛。(No.2 could not land and switched to go-around.)

(4) 僚機餘油 1300 磅。(No.2's remaining fuel was 1300 lb.)

(5) 二機分開。(2 aircrafts were separated.)

(O) 選項 (Options, 我有什麼樣的對應策略可選擇？- What strategies can be selected?)

(1) 重新加入 GCA 航線。(Re-join GCA flight pattern.)

(2) 轉降外場。(To land at the other base.)

(R) 危機與優勢 (Risk & Benefits, 不同策略有何不同的潛在危機與優勢？- Are there any risk and benefits for different strategies?)

(1) 天氣轉劣且剩餘油量低。(Weather was worse and remaining fuel was low.)

(2) 僚機操作能力與管制員的引導能力不足。(Both No.2 and ground controller were inexperienced.)

(3) 1300磅的餘油僅能容許三次GCA航線，憑增飛行員操作壓力。(The remaining fuel, 1300 lb, was only enough to fly GCA pattern for 3 times which increased pilot's pressure.)

(4) 花蓮機場天氣佳、距離近、環境熟，爲最佳之備降場。(YU was the most proper spare base for landing for it had the advantages of better weather, shorter distance and more familiar surroundings.)

(D) 決心 (Decision, 選定一最佳之策略- To select the best strategy.)

轉降花蓮基地。(Go to land at YU base.)

(E) 執行 (Execution, 執行此最佳策略並注意何時做？做什麼？如何做？-To execute this strategy and pay attention for when, what and how to do it.)

(1) 告知僚機及塔台轉降花蓮。(To inform the intention of landing at YU airbase to No.2 and Tower.)

(2) 請台東進場台優先引導定向花蓮機場，並告知花蓮進場台低油量訊息。(To ask TaiTung Approach to guide to YU with the first priority and inform YU those who had low fuel were allowed landing firstly.)

(3) 請台東進場台實施兩機航向與高度安全隔離並引導雲上集合。(To ask TaiTung Approach to guide 2 flights with the separation of heading and altitude and assemble together above clouds.)

(4) 指示僚機太康調向花蓮基地台並油門軍用以 300 浬爬升至雲上。(To direct No.2 adjust TACAN frequency to YU and climb to the top of clouds with the speed of 300 knots at military throttle.)

(C) 檢驗 (Check, 檢驗每個動作執行後對飛行安全所造成之影響- To check if each operation influences the flight safety.)

(1) 確認僚機領知轉降花蓮並避免不必要之耗油操作。(To affirm No.2 followed the command to land YU base and avoided consuming fuel for unnecessary operation.)

(2) 確認管制單位優先引導僚機進場 (To affirm ground control would guide No.2 to land with first priority.)

(1) 在此種放棄起飛的飛行情境中，您覺得 FOR-DEC 「飛行決策訓練」之「風險評估」的效率如何？（效率很高 9，尚可接受 5，效率很低 1，請圈選一個數字）

9 8 7 6 5 4 3 2 1

In this scenario, what do you think about the effectivness of FOR-DEC for situation assessment? (Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

(2) 在此種放棄起飛的飛行情境中，您覺得 FOR-DEC 「飛行決策訓練」之「危機管理」的效率如何？（效率很高 9，尚可接受 5，效率很低 1，請圈選一個數字）

9 8 7 6 5 4 3 2 1

In this scenario, what do you think about the effectiveness of FOR-DEC for risk management? (Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

(3) 在此種放棄起飛的情境中，您覺得 FOR-DEC 「飛行決策訓練」之「時間管理」的效率如何（能否即時應變）？（效率很高 9，尚可接受 5，效率很低 1，請圈選一個數字）

9 8 7 6 5 4 3 2 1

In this scenario, what do you think about the effectivness of FOR-DEC for response time? (Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

(4) 在此種飛行情境中，您覺得 FOR-DEC「飛行決策訓練」之「可行性」如何？
（可行性很高 9，尚可接受 5，可行性很低 1，請圈選一個數字）

9 8 7 6 5 4 3 2 1

In this scenario, what do you think about the overall applicability of FOR-DEC? (Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

****

SOAR「飛行決策訓練」

(S) 情境 (<u>S</u>ituation, 目前飛機、飛行環境、與飛行員之狀況如何？-What are the situations of the aircrafts, surroundings and pilots?)

(1) 本場天氣無法目視起降，必須仰賴 GCA 引導。(The home base weather did not allow taking-off and landing with visual flight and had to rely on GCA.)

(2) 僚機無法落地，呼叫重飛。(No.2 couldn't land so called out "Go around.")

(3) 僚機油量餘 1300 磅，在此情況下屬低油量。(No.2's remaining fuel was 1300 lb that was in the low fuel situation.)

(4) 長機於雲中爬升。(Leader was climbing in the dense clouds.)

(5) 二機分開無法目視彼此。(Leader and No.2 were separated and couldn't see each other.)

(O) 選項 (<u>O</u>ptions, 評估可選擇之策略有哪些？執行後會有哪些後果？選擇最佳策略-To evaluate feasible strategies, to figure out the possible results after executeing and to select the best strategy.)

(1) 重新加入 GCA 航線，二號機餘油雖足以執行三次 GCA，對飛行員造成較大壓力。(Although No.2's fuel was enough to fly GCA pattern for 3 rounds, No.2 suffered higher pressure.)

(2) 雲上集合後轉降外場，尤其花蓮機場爲台東基地飛行員常練習儀器穿降之基地，安全係數較高。(After assembling at the top of clouds the flight would ~~go to~~ land at YU airbase where ZN pilots usually practiced instrument flight.)

(A) 行動 (<u>A</u>ct, 執行所選擇之最佳策略，並注意對飛行情境所造成之變化-To execute the best strategy and watch out for surroundings' change.)

(1) 呼叫管制單位轉降花蓮。(To call out "Change landing into YU base".)

(2) 告知低油量訊息，請求優先引導僚機進場。(To inform No.2 had low fuel and request landing with the first priority.)

(R) 重複評估情境與選項 (<u>R</u>epeat, 重複評估飛機與飛行環境，選擇並執行最佳策略 -Repeat evaluation for aircraft, flight surroundings and pilots' condition; select and execute the best strategy.)

(1) 雲中儀器飛行嚴防空間迷向。(To watch out spatial disorientation when flying inside the clouds.)

(2) 避免不必要之耗油操作。(To avoid consuming fuel for unnecessary operation.)

(3) 依管制單位指示精確操作。(To follow the ground controller's direction to operate accurately.)

(1) **在此種放棄起飛的飛行情境中，您覺得 SOAR「飛行決策訓練」之「風險評估」的效率如何？**（效率很高 9，尚可接受 5，效率很低 1，請圈選一個數字）

9 8 7 6 5 4 3 2 1

In this scenario, what do you think about the effectivness of SOAR for situation assessment?

(Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

(2) **在此種放棄起飛的飛行情境中，您覺得 SOAR「飛行決策訓練」之「危機管理」的效率如何？**（效率很高 9，尚可接受 5，效率很低 1，請圈選一個數字）

9 8 7 6 5 4 3 2 1

In this scenario, what do you think about the effectiveness of SOAR for risk management?

(Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

(3) **在此種放棄起飛的情境中，您覺得SOAR「飛行決策訓練」之「時間管理」的效率如何（能否即時應變）？**（效率很高9，尚可接受5，效率很低1，請圈選一個數字）

9 8 7 6 5 4 3 2 1

In this scenario, what do you think about the effectivness of SOAR for response time?

(Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

(4) **在此種飛行情境中，您覺得 SOAR「飛行決策訓練」之「可行性」如何？**

（可行性很高 9，尚可接受 5，可行性很低 1，請圈選一個數字）

9 8 7 6 5 4 3 2 1

In this scenario, what do you think about the overall applicability of SOAR?

(Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

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DESIDE「飛行決策訓練」

(D) 察覺 (Detect, 覺察飛行環境與飛機狀況是否有異常-To detect if there are any unusual condition about the surroundings and aircraft.)

(1) 本場天氣無法目視起降，必須仰賴 GCA 引導，二號機餘油餘 1300 磅雖尚可三次 GCA 航線操作，但對飛行員產生較大壓力。(The home base weather did not allow taking-off and landing with visual flight and had to rely on GCA; although No.2's remaining fuel, 1300 lb, was enough to fly GCA pattern for 3 rounds, it increased pilot's pressure.)

(2) 僚機無法落地且低油量，因此轉降臨近且熟悉之外場爲較安全之選項。(No.2 couldn't land and had low fuel, so it would be safe option to land at the other ~~one~~ base where the distance was short and pilots were familiar with.)

(E) 估計 (Estimate, 根據所覺察之飛行狀況，評估對飛安之影響-To evaluate the influence on the flight safety based on flying condition.)

(1) 僚機油量可實施三次 GCA 航線，但其儀飛能力與管制官引導能力均不確定？(No.2's remaining fuel was enough to fly GCA pattern for 3 rounds, but both pilot's ability of instrument flight and controller's experience were uncertainty.)

(2) 油量足以轉降外場，但決心必須馬上下達，以避免油量平白消耗。(The fuel was enough to land at the other base, yet the determination had to be made immediately to avoid unnecessary consumption.)

(3) 花蓮機場爲最熟悉之外場且天氣佳，依二號機油量，亦不容許決心延遲。(The determination couldn't be delayed although YU was the airbase where pilots were most familier with and the weather was good for landing.)

(S) 設立安全目標 (Set Safety Objectives, 尋找是否有較好的解決策略？-Are there any more proper strategy?)

安全轉降外場。(To land at the spare base, YU.)

(I) 確認 (Identify, 是否有足夠的時間收集更多訊息，並評估行動策略-Is the time enough to collect more information and evaluate strategies.)

轉降花蓮機場爲最安全之決定。(The safest determination was to land YU base.)

(D) 行動 (Do, 執行最佳行動策略-Take action.)

(1) 呼叫僚機及管制單位轉降花蓮。(To call ground controller guiding No.2 to land at YU.)

(2) 請台東進場台優先引導僚機定向花蓮機場，並告知花蓮進場台低油量訊息。(To ask ZN Approach to guide No.2 to land at YU with the first priority and inform YU Approach about No.2's low fuel condition.)

(3) 指示僚機太康調向花蓮基地台並油門軍用以 300 浬爬升至雲上。(To direct No.2 adjust TACAN frequency to YU and climb to the top of clouds with the speed of 300 knots at military throttle.)

(E) 評量 (Evaluate, 評量行動後對飛行安全有何影響？並繼續再注意覺察飛行情境之變化-To evaluate the influence after taking action and continue watching for the changes of flying condition.)

(1) 嚴防空間迷向。(To keep a sharp lookout for avoiding spatial disorientation.)
(2) 避免不必要之耗油操作。(To avoid consuming fuel for unnecessary operation.)
(3) 依管制單位指示精確操作。(To follow ground controller’s direction to operate accurately.)

(1) 在此種放棄起飛的飛行情境中，您覺得 DESIDE「飛行決策訓練」之「風險評估」的效率如何？（效率很高 9，尚可接受 5，效率很低 1，請圈選一個數字）

9 8 7 6 5 4 3 2 1

In this scenario, what do you think about the effectivness of DESIDE for situation assessment?

(Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

(2) 在此種放棄起飛的飛行情境中，您覺得 DESIDE「飛行決策訓練」之「危機管理」的效率如何？（效率很高 9，尚可接受 5，效率很低 1，請圈選一個數字）

9 8 7 6 5 4 3 2 1

In this scenario, what do you think about the effectiveness of DESIDE for risk management?

(Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

(3) 在此種放棄起飛的情境中，您覺得 DESIDE「飛行決策訓練」之「時間管理」的效率如何（能否即時應變）？（效率很高 9，尚可接受 5，效率很低 1，請圈選一個數字）

9 8 7 6 5 4 3 2 1

In this scenario, what do you think about the effectivness of DESIDE for response time?

(Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

(4) 在此種飛行情境中，您覺得 DESIDE「飛行決策訓練」之「可行性」如何？（可行性很高 9，尚可接受 5，可行性很低 1，請圈選一個數字）

9 8 7 6 5 4 3 2 1

In this scenario, what do you think about the overall applicability of DESIDE?

(Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

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狀況：左右發電機失效 (both generators go out at the same time in the tactical maneuver).

一、狀況：

少校教官駕 F-5F 000 號機，於 1010 時起飛，航路及空域天氣狀況為能見度 3 哩，雲高 2000 ~ 10000 呎，1020 分實施懶 8 字時，主警告燈發亮，檢查警告燈板，左右發電機失效燈發亮，使用復位電門仍無效。 (A Lieutenant pilot was in the front seat and a Major instructor pilot was in the rear seat flyiong an F-5F to airspace for transition training. When they flew the Lazy 8, the master caution light started blinking. Simultaneously, left and right generators' alert lights came on even though the switch had been reset.)

二、問題：

請問貴官如何處置？ (What would you do if you were the pilot?)

（**請做完後面五頁之後，再填寫此處**- Please read the questions on the following 5-pages first, and then answer the questions here）

三、針對「左右發電機失效」的狀況

(1) SHOR, (2) PASS, (3) FOR-DEC, (4) SOAR, (5) DESIDE

此五種「飛行決策」訓練方式，您認爲哪一種是最佳之訓練方式？理由爲何？

(Which ADM mnemonic is the best approach for this situation? And Why?)

SHOR「飛行決策訓練」

(S) 刺激 (<u>S</u>timuli, 指飛行員感受到外在環境之變化-Pilot perceives surroundings change.)

(1) 主警告燈亮。(The master caution light was blinking.)
(2) 左右發電機失效燈亮。(Left and right generators' alert lights were lit.)
(3) 電門復位故障排除無效，確認非單純斷電器跳脫。(It didn't work to reset the switch that was identified the problem wasn't simply circuit breaker popped out.)

(H) 假設 (<u>H</u>ypotheses, 針對新訊息(刺激)提假設，例如是否有安全顧慮？-Hypotheses for new information (stimulation), for example, "Is anything dangerous?")

研判左右發電機均失效，電瓶僅能提供九分鐘之電力供應且部分裝備無法操作。(The situation was deduced that left and right generators were out and the battery could only provide power for 9 minutes, besides, some equipment couldn't be operated.)

(O) 選擇 (<u>O</u>ptions, 現在最重要的是做什麼？該如何做？-What thing would be the first priority to do now? How to do?)

(1) 立即停止訓練。(To stop training immediately.)
(2) 呼叫管制單位標定位置並請求優先引導返航。(To ask ground control to locate aircraft's position and request guiding to home base with first priority.)
(3) 盡量節約電力。(To economize power with the greatest possibility.)

(R) 行動反應 (<u>R</u>esponse, 採取行動，做什麼？如何做？何時做？到哪裡？**...**-To take action. What to do? How to do? When to do? Where to go?...)

(1) 立即停止訓練並向管制單位宣告緊急狀況。(To stop training immediately and announce the emergency situation to ground control.)
(2) 關掉不必要電氣裝備，以節約電瓶電源 (To shut off unnecessary electrical equipment for saving battery power.)
(3) 採長五邊、無襟翼進場。(To join long final straight-in without flaps.)
(4) 必要時使用起落架替用伸放。(To operate landing gear alternate extension when necessary.)

(1) **在此種放棄起飛的飛行情境中，您覺得 SHOR「飛行決策訓練」之「風險評估」的效率如何？**（效率很高 9，尚可接受 5，效率很低 1，請圈選一個數字）

9　8　7　6　5　4　3　2　1

In this scenario, what do you think about the effectivness of SHOR for situation assessment? (Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

(2) **在此種放棄起飛的飛行情境中，您覺得 SHOR「飛行決策訓練」之「危機管理」的效率如何？**（效率很高 9，尚可接受 5，效率很低 1，請圈選一個數字）

9　8　7　6　5　4　3　2　1

In this scenario, what do you think about the effectiveness of SHOR for risk management? (Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

(3) 在此種放棄起飛的情境中，您覺得SHOR「飛行決策訓練」之「時間管理」的效率如何（能否即時應變）？（效率很高9，尚可接受5，效率很低1，請圈選一個數字）

9 8 7 6 5 4 3 2 1

In this scenario, what do you think about the effectivness of SHOR for response time?
(Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

(4) 在此種飛行情境中，您覺得 SHOR「飛行決策訓練」之「可行性」如何？（可行性很高9，尚可接受5，可行性很低1，請圈選一個數字）

9 8 7 6 5 4 3 2 1

In this scenario, what do you think about the overall applicability of SHOR?
(Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

****

PASS「飛行決策訓練」

(P) 確認問題 (Problem identification, 辨明目前所處的環境及問題所在-To identify surroundings and problems at present.)

(1) 左右發電機均失效。(Both left and right generators were out of condition.)

(2) 襟翼伸放、姿態儀、航向儀、導航裝備、安定增大器、發動機儀表、配平、高度表(電氣方式)、CADC、輔助進氣門開啓等裝備功能亦隨之失效。(The following equipment would be failed, including the flaps extension(control), altitude indicator, horizontal situation indicator, navigational equipment, damper, engine instruments, trim, altimeter(Elect), CADC and aux inletdoor control.)

(A) 取得訊息 (Acquire information, 蒐集與問題有關之訊息-To collect information concerning problems. **)**

(1) 以復位電門方式處理仍無效。(It didn't work for reseting the switches.)

(2) 機內相關電氣導航數據均無法參考。(All data from electrical equipment couldn't be used.)

(3) 備用陀螺儀爲航向之主要參考。(Spare gyro was the main heading reference.)

(4) 以管制單位提供訊息爲主參考。(The information provided by ground control was the main reference.)

(S) 檢驗策略 (Survey strategy, 檢驗解決問題之相關策略之優點與缺點- To survey the strength and weakness of strategies for solving problems.)

(1) 立即停止訓練，下降高度至雲下目視。(To stop training immediately and descending until below clouds.)

(2) 呼叫管制單位標定位置並請求優先引導返航，以節省不必要之油電消耗。(To request ground control to locate the aircraft position and guide to home base with first priority for avoiding unnecessary consumption of fuel and electricity.)

(S) 選擇策略 (Select strategy, 選擇最佳策略並執行- To choose the most proper strategy and take action.**)**

(1) 立即停止訓練。(To stop training immediately.)

(2) 關掉不必要電氣裝備，以節約電瓶電源 (To shut off unnecessary electrical equipment for saving battery power.)

(3) 呼叫航戰管標定位置並請求優先引導返航。(To request ground control to locate aircraft position and guide to home base with first priority.)

(4) 附近如有在空機，請航戰管引導集合，隨伴友機返航。(To request ground control to guide to assemble for formation to home base if there was the other friend aircraft nearby.)

(5) 採長五邊、無襟翼進場。(To adopt long final approach without flaps.)

(6) 必要時使用起落架替用伸放。(To operate landing gear alternate extension when necessary.)

(1) 在此種放棄起飛的飛行情境中，您覺得 PASS「飛行決策訓練」之「風險評估」的效率如何？（效率很高 9，尚可接受 5，效率很低 1，請圈選一個數字）

9 8 7 6 5 4 3 2 1

In this scenario, what do you think about the effectivness of PASS for situation assessment?

(Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

(2) 在此種放棄起飛的飛行情境中，您覺得 PASS 「飛行決策訓練」之「危機管理」的效率如何？（效率很高 9，尚可接受 5，效率很低 1，請圈選一個數字）

9 8 7 6 5 4 3 2 1

In this scenario, what do you think about the effectiveness of PASS for risk management?

(Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

(3) 在此種放棄起飛的情境中，您覺得 PASS 「飛行決策訓練」之「時間管理」的效率如何（能否即時應變）？（效率很高9，尚可接受5，效率很低1，請圈選一個數字）

9 8 7 6 5 4 3 2 1

In this scenario, what do you think about the effectivness of PASS for response time?

(Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

(4) 在此種飛行情境中，您覺得 PASS「飛行決策訓練」之「可行性」如何？

（可行性很高 9，尚可接受 5，可行性很低 1，請圈選一個數字）

9 8 7 6 5 4 3 2 1

In this scenario, what do you think about the overall applicability of PASS?

(Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

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FOR-DEC「飛行決策訓練」

(F) 實況 (Facts, 此時此地發生什麼狀況？-What's happening now?)
  (1) 主警告燈亮。(The master caution light was blinking.)
  (2) 左右發電機失效燈亮。(Both left and right generator caution lights were lit.)
  (3) 電門復位仍無法故障排除。(It didn't work to reset the switches.)
  (4) 確定左右發電機已失效。(It could be sure that left and right generators were out of condition.)

(O) 選項 (Options, 我有什麼樣的對應策略可選擇？- What strategies can be selected?)
  (1) 立即停止訓練並宣告緊急狀況。(To stop training immediately and announce a state of emergency.)
  (2) 呼叫航戰管標定位置並請求優先引導返航。(To request ground control to locate aircraft position and guide to home base with first priority.)
  (3) 請管制單位引導在空機與我集合。(To request ground control to guide the other friend aircraft nearby to assemble for formation.)

(R) 危機與優勢 (Risk & Benefits, 不同策略有何不同的潛在危機與優勢？- Are there any risk and benefits for different strategies?)
  (1) 左右發電機均失效後，電瓶僅能供應九分鐘，須立即停止訓練。(After left and right generators were out of condition, the battery could only provide power for 9 minutes and the training had to be stopped immediately.)
  (2) 不宜高動力飛行。(Flying with high power was improper.)
  (3) 襟翼伸放、姿態儀、航向儀、導航裝備、安定增大器、發動機儀表、配平、高度表(電氣方式)、CADC、輔助進氣門開啓等裝備功能將伴隨失效。(The following equipment would be failed, including the flaps extension(control), altitude indicator, horizontal situation indicator, navigational equipment, damper, engine instruments, trim, altimeter(Elect), CADC and aux inletdoor control.)
  (4) 須靠航戰管標定位置與引導。(It was necessary to rely on the guidance by ground control.)
  (5) 安全係數降低，若有在空機編隊返航可增加操作依據與安全。(Owing to lower safety factor, it would increase safety and operation reference if the other friend aircraft nearby could assemble together to return base.)

(D) 決心 (Decision, 選定一最佳之策略- To select the best strategy.)
  (1) 立即停止訓練並宣告緊急狀況。(To stop training immediately and announce a state of emergency.)
  (2) 關掉不必要電氣裝備，以節約電瓶電源。(To shut off unnecessary electrical equipment for saving battery power.)
  (3) 呼叫航戰管標定位置並請求優先引導返航。(To request ground control to locate aircraft position and guide to home base with first priority.)
  (4) 附近如有在空機，請管制單位引導與我集合，隨伴友機返航。(To request ground control to guide to assemble for formation to home base if there was ~~the~~ other friend aircraft nearby.)

(E) 執行 (Execution, 執行此最佳策略並注意何時做？做什麼？如何做？-To execute this strategy and watch out for when, what and how to do it.)
  (1) 立即停止訓練並關掉不必要電氣裝備，以節約電瓶電源。(To stop training immediately and shut off unnecessary electrical equipment for saving battery power.)
  (2) 呼叫航戰管標定位置並請求優先引導返航。(To request ground control to locate aircraft position and guide to home base with first priority.)

(3) 附近如有在空機，請航戰管引導集合，隨伴友機返航。(To request ground control to guide to assemble for formation to home base if there was ~~the~~ other friend aircraft nearby.)
(4) 採長五邊、無襟翼進場。(To adopt long final approach without flaps.)
(5) 必要時使用起落架替用伸放。(To operate landing gear alternate extension when necessary.)

(C) 檢驗 (Check, 檢驗每個動作執行後對飛行安全所造成之影響- To check if each operation influences the flight safety. **)**

(1) 航戰管提供數據爲修正與操作依據。(The data provided by ground control was the main reference for adjustment and operation.)
(2) 如有友機隨伴，則以友機爲操作依據。(If there were the other friend aircraft for formation, it would be the main reference.)
(3) 從左右發電機失效時間計算九分鐘，以掌握電瓶可用時間 (To count 9 minutes from generators' fail for knowing battery's available time.)

(1) **在此種放棄起飛的飛行情境中，您覺得** FOR-DEC **「飛行決策訓練」之「風險評估」的效率如何？（效率很高** 9**，尚可接受** 5**，效率很低** 1**，請圈選一個數字）**

9 8 7 6 5 4 3 2 1

In this scenario, what do you think about the effectivness of FOR-DEC for situation assessment? (Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

(2) **在此種放棄起飛的飛行情境中，您覺得** FOR-DEC **「飛行決策訓練」之「危機管理」的效率如何？（效率很高** 9**，尚可接受** 5**，效率很低** 1**，請圈選一個數字）**

9 8 7 6 5 4 3 2 1

In this scenario, what do you think about the effectiveness of FOR-DEC for risk management? (Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

(3) **在此種放棄起飛的情境中，您覺得** FOR-DEC **「飛行決策訓練」之「時間管理」的效率如何（能否即時應變）？（效率很高**9**，尚可接受**5**，效率很低**1**，請圈選一個數字）**

9 8 7 6 5 4 3 2 1

In this scenario, what do you think about the effectivness of FOR-DEC for response time? (Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

(4) **在此種飛行情境中，您覺得** FOR-DEC**「飛行決策訓練」之「可行性」如何？（可行性很高** 9**，尚可接受** 5**，可行性很低** 1**，請圈選一個數字）**

9 8 7 6 5 4 3 2 1

In this scenario, what do you think about the overall applicability of FOR-DEC? (Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

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SOAR「飛行決策訓練」

(S) 情境 (Situation, 目前飛機、飛行環境、與飛行員之狀況如何？-What are the situations of aircrafts, surroundings and pilots?)

(1) 左右發電機均失效，電瓶僅能提供九分鐘電力。(After left and right generators were out of condition, the battery could only provide power for 9 minutes)

(2) 前後座飛行員共同處置有助操作(因配平失效，桿上壓力大)。(It would be helpful for controlling aircraft if the front and the back seat pilots had well cooperation, because the pressure on stick was very high due to trimmer fail.)

(3) 襟翼伸放、姿態儀、航向儀、導航裝備、安定增大器、發動機儀表、配平、高度表(電氣方式)、CADC、輔助進氣門開啓等裝備功能亦隨之失效。(The following equipment would be failed, including the flaps extension(control), altitude indicator, horizontal situation indicator, navigational equipment, damper, engine instruments, trim, altimeter(Elect), CADC and aux inletdoor control.)

(4) 僅能依據航戰管指示或與在空友機編隊返場。(The reference for flying was only from ground control or friend aircraft that made a formation with.)

(O) 選項 (Options, 評估可選擇之策略有哪些？執行後會有哪些後果？選擇最佳策略-To evaluate feasible strategies, to figure out the possible results after executeing and to select the best strategy.)

(1) 呼叫航戰管標定位置並請求優先引導返航。(To request ground control to locate aircraft position and guide to home base with the first priority.)

(2) 若有在空友機，請管制單位引導以編隊返航方式可提高安全係數。(It would increase safety factor if there were other friendly aircraft nearby that can assemble together for returning base.)

(3) 避免儀器飛行環境。(The surroundings of instrument flight should be avoided.)

(A) 行動 (Act, 執行所選擇之最佳策略，並注意對飛行情境所造成之變化-To execute the best strategy and watch out surroundings' change.)

(1) 立即停止訓練。(To stop training immediately.)

(2) 呼叫航戰管標定位置並請求優先引導返航。(To request ground control to locate aircraft position and guide to home base with the first priority.)

(3) 附近若有在空友機，請航戰管引導集合以編隊協助返航。(It would be helpful for returning to base if there were ~~the~~ other friend aircraft nearby that can assemble together.)

(R) 重複評估情境與選項 (Repeat, 重複評估飛機與飛行環境，選擇並執行最佳策略 -Repeat evaluation for aircraft, flight surroundings and pilots' condition; select and execute the best strategy.)

(1) 航戰管提供數據爲修正與操作依據。(The data provided by ground control was the main reference for adjustment and operation.)

(2) 如有友機隨伴，則以友機爲操作依據。(If there were the other friend aircraft for formation, it would be the main reference.)

(3) 從左右發電機失效時間計算九分鐘，以掌握電瓶可用時間。(To count 9 minutes from generators' fail for knowing battery's available time.)

(4) 評估雲下目視之環境與到達機場之距離。(To evaluate the operation surroundings under clouds and calculate the distance to base.)

(1) **在此種放棄起飛的飛行情境中，您覺得 SOAR「飛行決策訓練」之「風險評估」的效率如何？**（效率很高 9，尚可接受 5，效率很低 1，請圈選一個數字）

9 8 7 6 5 4 3 2 1

In this scenario, what do you think about the effectivness of SOAR for situation assessment?

(Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

(2) **在此種放棄起飛的飛行情境中，您覺得 SOAR「飛行決策訓練」之「危機管理」的效率如何？**（效率很高 9，尚可接受 5，效率很低 1，請圈選一個數字）

9 8 7 6 5 4 3 2 1

In this scenario, what do you think about the effectiveness of SOAR for risk management?

(Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

(3) **在此種放棄起飛的情境中，您覺得 SOAR「飛行決策訓練」之「時間管理」的效率如何（能否即時應變）？**（效率很高 9，尚可接受 5，效率很低 1，請圈選一個數字）

9 8 7 6 5 4 3 2 1

In this scenario, what do you think about the effectivness of SOAR for response time?

(Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

(4) **在此種飛行情境中，您覺得 SOAR「飛行決策訓練」之「可行性」如何？**
（可行性很高 9，尚可接受 5，可行性很低 1，請圈選一個數字）

9 8 7 6 5 4 3 2 1

In this scenario, what do you think about the overall applicability of SOAR?

(Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

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DESIDE「飛行決策訓練」

(D) 察覺 (Detect, 覺察飛行環境與飛機狀況是否有異常-To detect if there were any unusual condition about surroundings and aircraft.)

(1) 主警告燈亮。(The master caution light was blinking.)

(2) 左右發電機失效燈亮。(Both left and right generator caution lights were lit.)

(3) 電門復位仍無法故障排除。(It didn't work to reset the switches.)

(4) 姿態儀與航向儀等重要儀表無法參考，備用陀螺儀爲唯一參考，但有遲滯現象。(Instruments couldn't provide correct attitude and heading and the spare gyro was the only one reference but it would have slow-moving phenomenon.)

(E) 估計 (Estimate, 根據所覺察之飛行狀況，評估對飛安之影響-To evaluate the influence on flight safety based on the flying condition.)

(1) 左右發電機失效將導致襟翼伸放、姿態儀、航向儀、導航裝備、安定增大器、發動機儀表、配平、高度表(電氣方式)、CADC、輔助進氣門開啓等裝備功能失效，必須立即停止訓練並返航。(The following equipment would be failed, including the flaps extension (control), altitude indicator, horizontal situation indicator, navigational equipment, damper, engine instruments, trim, altimeter(Elect), CADC and aux inletdoor control, therefore it was required to terminate training immediately and return to base.)

(2) 電瓶僅能供應九分鐘，應避免高動力飛行且關閉不必要電器，以減輕電瓶負擔。(The battery could only provide power for 9 minutes, so shutting off unnecessary electrical equipment for saving battery power in order to lessen battery's load.)

(3) 須靠航戰管標定位置與引導，因爲發電機失效後的導航資料已不足採信。(To rely on ground control's guidance was required because the navigation data was no more correct after generators failed.)

(4) 返航操作之安全係數降低，若有在空機編隊返航可增加操作依據與安全。(Owing to lower safety factor for flight, it would increase safety and operation reference if the other friend aircraft nearby could assemble together to return base.)

(S) 設立安全目標 (Set Safety Objectives, 尋找是否有較好的解決策略？-Are there any more proper strategy?)

(1) 掌握飛機動態安全落地。(To master aircraft's situation for safe landing.)

(I) 確認 (Identify, 是否有足夠的時間收集更多訊息，並評估行動策略-Is time enough to collect more information and evaluate strategies.)

(1) 呼叫航戰管標定位置並請求優先引導返航。(To request ground control to locate aircraft position and guide to home base with first priority.)

(2) 附近若有在空友機，請航戰管引導集合以編隊協助返航，以提高安全係數。(It would increase the safety factor for returning base if there were the other friend aircraft nearby that can assemble together.)

(3) 確認雲下目視飛行之可能性。(To identify the possibility to fly under clouds.)

(D) 行動 (Do, 執行最佳行動策略-Take action.)

(1) 立即停止訓練。(To stop training immediately.)

(2) 呼叫航戰管標定位置並請求優先引導返航。(To request ground control to locate aircraft position and guide to home base with first priority.)

(3) 附近若有在空友機，請航戰管引導集合以編隊協助返航。(It would be helpful for returning base if there were ~~the~~ other friend aircraft nearby that can assemble together.)

(E) 評量 (Evaluate, 評量行動後對飛行安全有何影響？並繼續再注意覺察飛行情境之變化-To evaluate the influence after taking action and continue watching for the changes of flying condition.)

(1) 航戰管提供數據爲修正與操作評量。(The data provided by ground control was the main reference for adjustment and operation.)

(2) 如有友機隨伴，則以友機爲操作評量。(If there were ~~the~~ other friend aircraft for formation, it would be the main reference.)

(3) 從左右發電機失效時間計算九分鐘，以評量電瓶可用時間與到達機場之距離。(To count 9 minutes from generators' fail for knowing battery's available time and calculating the distance to base.)

(1) **在此種放棄起飛的飛行情境中，您覺得 DESIDE「飛行決策訓練」之「風險評估」的效率如何？（效率很高 9，尚可接受 5，效率很低 1，請圈選一個數字）**

9 8 7 6 5 4 3 2 1

In this scenario, what do you think about the effectivness of DESIDE for situation assessment?

(Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

(2) **在此種放棄起飛的飛行情境中，您覺得 DESIDE「飛行決策訓練」之「危機管理」的效率如何？（效率很高 9，尚可接受 5，效率很低 1，請圈選一個數字）**

9 8 7 6 5 4 3 2 1

In this scenario, what do you think about the effectiveness of DESIDE for risk management?

(Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

(3) **在此種放棄起飛的情境中，您覺得DESIDE「飛行決策訓練」之「時間管理」的效率如何（能否即時應變）？（效率很高9，尚可接受5，效率很低1，請圈選一個數字）**

9 8 7 6 5 4 3 2 1

In this scenario, what do you think about the effectivness of DESIDE for response time?

(Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

(4) **在此種飛行情境中，您覺得 DESIDE「飛行決策訓練」之「可行性」如何？（可行性很高 9，尚可接受 5，可行性很低 1，請圈選一個數字）**

9 8 7 6 5 4 3 2 1

In this scenario, what do you think about the overall applicability of DESIDE?

(Very high: 9, Acceptable: 5, Very low: 1, Please select one number.)

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Appendix B (Scenarios for Pre-training)

姓名(Name)：

年齡(Age)：

飛行時數(Flight hours)：

中尉學官駕 F-5E 實施 TF/BFM 課目二號機，1350 進跑道試車一切正常，1351 與長機編隊起飛，滾行中飛機有超前長機趨勢，收油門至 A/B 位置後可保持正常編隊,至 150 浬突聞長機呼叫 Lead 放棄起飛。(*Scenario 1: F-5E No. 2 wingman has to make a decision as the No. 1 (Leader) abandons a tactical formation take-off at 145 knots*)

請問貴官為二號機應如何處置？ (What would you do if you were No. 2 ?)

中尉學官駕 F-5E 於起飛滾行中發動機加速正常，165 浬帶桿飛機鼻輪離地時，忽聞發動機'碰'一聲，推力消失。(*Scenario 2: F-5E right engine fails as a result of Foreign Object Damage (FOD) just as the nose gear leaves the ground at a speed 165 knots.*)

*請問貴*官應如 *何*處置 *?* (What would you do if you were the pilot ?)

中尉學官駕 F-5E 任 GCI 四號機，1322 時自台東基地起飛，1410 課目結束返降，高度 1500 呎保持左梯隊實施衝場，因能見度影響未能對正跑道，即向右轉向三

邊，準備重新加入衝場，於二邊轉三邊時進雲，4 號機位於最左側位置，因雲層影響，於轉彎中迷失長機。（*Scenario 3: No. 4 in a tactical formation of F-*5Es *is required to make a decision when No. 1 (Leader) becomes lost in cloud during formation flight (3 feet distance between wing tips of the four fighters)*

請問貴官為四號機應*如何處置？*（What would you do if you were the No.4？）

中尉學官駕 F-5E 擔任 GCI 課目之二號機，於 1100 起飛至 ZE 空域，先由 1、2 號機擔任攔截機高度 20M，3、4 號機任目標機高度 22M，於第 3 次航線由 2 號機任前位機，長機保持戰鬥僚機位置，3、4 號機保持防禦隊形實施 1 對 2 演練，在戰管引導至 6 浬時，2 號目視 3、4 號機，即開始佔位接敵，3、4 號機亦實施兩機防禦操作，於第一次對頭通過再回頭時，3、4 號機呼叫未發現 1、2 號機，2 號機呼叫目視一架在 12 點半同高度，對頭接近中。（*Scenario 4: F-5E leader (No. 1) of 4 aircraft needs to make a decision for the No.3 and No. 4 aircraft when a 'no joy' call (no visual contact with No. 1 and No. 2) is made and No. 2 calls 'one opposing target approaching on 12:30 o'clock with same altitude'. This occurs during practice of a 2 versus 2 engagement (Air Combat Manoeuvre*)

請問貴官為 1 號*機應如何處置？*（What would you do if you were the leader？）

少校教官駕 f-5E 任 TF 課目之長機，中尉學官駕 F-5E 任僚機，0745 時自台東起飛至 ZJ 空域實施訓練，0830 時訓練完畢返航，當時戰管提示本場天氣漸趨轉劣，僚機呼叫重飛，因下滑未目視跑道，待目視後已與跑道成大偏角，無法安全落地，當時餘油僅剩 800 磅。（*Scenario 5: Both the leader and wingman in a formation of F-5Es are unable to land at home-base in a 'bingo' (low fuel) situation during instrument flight in bad weather* ）

*請問貴官為長機應*如何*處置？*（What would you do if you were the leader？）

中尉學官駕 F-5E 至空域實施懶 8 字時，主警告燈發亮，檢查警告燈板，左右發電機失效燈發亮，使用復位電門仍無效。(*Scenario 6: When flying an F-5F both left and right generators fail at the same time during a tactical maneuver*)

*請問貴官應如何*處置 ？ (What would you do if you were the pilot ?)

Appendix C (Scenarios for Post-training)

姓名(Name)：

年齡(Age)：

飛行時數(Flight hours)：

中尉學官駕F-5E實施TF/BFM課目二號機,1330進跑道停於長機左側編隊起飛,試車時由於飛機煞車量不足，致飛機微量向前移動，經增加腳踏板壓力使飛機有效停妥，試車時飛機一切正常，1332時即跟隨長機訊號滾行，鬆煞車開油門最大時飛機有急促向右偏向長機之現象。（Scenario 1: *F-5E No. 2 wingman practicing tactical formation training. During the take off run with the throttles at maximum, No.1 (leader) suddenly slants seriously towards the No.2.*）

請問貴官為二號機應如何處置？（What would you do if you were the No.2 ?）

中尉學官駕F-5E於單機起飛後，保持十度仰角離場，此時高度800呎，速度250浬，突覺碰碰兩聲發動機有衝激現象，檢查儀表發現右發動機EGT明顯上升，轉速下掉。（Scenario 2: *F-5E solo, after taking off at 500 feet, pilot hears two unusual sounds from the engines and feels the aircraft shake. Engine EGT (Exhaust Gas Temperature) is increased, and RPM decreased.*）

請問貴官應如何處置？（What would you do if you were the pilot?）

少校教官駕F-5E任長機，中尉學官駕F-5E任二號機，於0930時自台東基地編隊起飛，二號機保持於左側疏開隊形，一切正常。離場過程轉向090度航向、高度13M，0935時戰管呼叫有一不明機在1點5浬，隨即二號機目視民航機在正前方3浬同高度，對頭接近中(長機尚未有任何指示)（Scenario 3: *F-5E leader while maintaining easy formation with No. 2 on the left, at 13000 feet, the GCI (Ground Control Intercept) reports an unidentified aircraft at one o'clock and 5 miles away. At the same time No.2 visuals an airliner in front and head-on 3 miles away with same altitude and approaching fast (leader had no orders)*）

請問貴官為二號機應如何處置？（What would you do if you were the No.2?）

中尉學官駕 F-5E 擔任基本攻防（BFM）二號機，於操作機砲攻擊時，發現距離距長機約 500 呎、偏角大於 90 度、高度差不足(同平面)且接近率大（空速 480 浬），極有碰撞之可能。（Scenario 4: Leader *and No.2 is practicing BFM (Basic Fighting Manoeuvres) for a gunshot attack, the distance between No. 2 and the leader is only 500 feet, the angle off is over 90 degrees. The possibility of a mid-air collision is high as both aircraft are at 480 knots and same altitude*）

請問貴官為二號機應如何處置？（What would you do if you were the No.2?）

中尉學官駕 F-5E 實施 BFM 課目，1040 由台東起飛至 ZH 空域練習，1100 課目完畢返航時，戰管廣播本場天氣轉劣，現已降水且低於起降標準請在空機注意油量。當時立即檢查油量僅剩 1400 磅，詢問本島天氣狀況、各基地天氣、助航設施。（Scenario 5: *F-5E is finishing the BFM training, the GCI reports that home base weather is worsening. Surplus fuel is down to only 1400 lb. The pilot asks for weather conditions at alternative airports*）

基地	能見度	雲層
MQ	9999 M	3000 呎疏雲
KU	6000 M	1500 呎疏雲;6000 呎裂雲
WS	5000 M	1500 呎裂雲;5000 呎密雲
YU	5000 M	1500 呎密雲

請問貴官應如何處置？（What would you do if you were the pilot?）

中尉學官駕 F-5E 實施 TF 單飛訓練，任二號機，1120 時起飛至空域，空中課目一切正常，1200 返降於三邊放下起落架時，發現手柄紅燈持續發亮，鼻輪指示燈不亮。（Scenario 6: *When an F-5E is lowering the landing gear while on the down-wind leg the landing gear shaft warning light illuminates, indicating the nose landing gear is abnormal*）

請問貴官應如何處置？（What would you do if you were the pilot?）