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EXPLORING THE INFLUENCE OF TIME PRESSURE ON DECISION-MAKING BY AIRLINE PILOTS

A thesis presented in partial fulfilment of the requirements for the degree of
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Srinivas Rao
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ABSTRACT

Decision-making errors have figured predominantly in many aviation accidents; often these have been due to stress and time pressure in solving a problem. The purpose of this study was to investigate the perceived effect of time pressure on airline pilots in decision-making. Specifically, the aim of the study was to improve the understanding of the influence of experience, crew position, confidence, perception of safety, stress, and training on decision-making by airline pilots. The study utilized an experimental design and survey methodology among a purposive sample of airline pilots. Evidence was found in the study to suggest that time pressure influences decision-making. Additionally, there was a significant lowering of decision-making ability in co-pilots with low experience when subjected to time pressure. An unexpected finding was the airline crew utilizing a decision-making model appeared to have no advantage over those who did not utilize decision-making model. Time pressure did not appear to influence post-decisional confidence in decision quality. Use of decision-making models did not have any positive impact on decision outcome. This finding may be due to the survey design in presenting sufficient diagnostic cues to participating pilots to draw on their experience and make better decisions. However, post-decisional safety perception was significantly affected by time pressure. Lastly, the findings from the present study suggested that the pilots with low experience seemed to suffer significantly on decision-making ability when under time pressure. The implications of these findings are discussed further.

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ABBREVIATIONS

AAIB	Air Accidents Investigation Board
ADM	Aeronautical Decision-Making
ANOVA	Analysis of Variance
ASN	Aviation Safety Network
ASRS	Aviation Safety Reporting System
ATSB	Australian Transportation Safety Bureau
CAA	Civil Aviation Authority
CAE	Canadian Aviation Electronics Limited
CAP	Civil Aviation Procedures
CRM	Crew Resource Management
DAAIB	Dutch Aviation Accident Inquiry Board
FAA	Federal Aviation Administration
FAA AC	Federal Aviation Administration Advisory Circular
FORDEC	Facts, Options, Risks, Decide, Execute, Check
ICAO	International Civil Aviation Organization
MUHEC	Massey University Human Ethics Committees
NDM	Naturalistic Decision-Making
NTSB	National Transportation Safety Bureau
RPD	Recognition Primed Decision-Making
SPSS	IBM Statistical Software Package

CHAPTER ONE

Introduction

1.1. Overview of the influence of time pressure on Decision-Making

Since the Wright Brothers' first flight, in a little over 100 years, aviation has gone from being highly risky to the safest mode of transport available. Most of the risk of flight occurs in the drive to the airport. Nowadays, the residual risk in flying is associated with human error, which remains the primary cause of airline crashes. The airline industry attempts to prevent problems associated with the human element by focussing on procedures and training (Chavis & Patsalides, 2010).

International Civil Aviation Organization (ICAO, 2017) analysis of aircraft accidents between 2012 and 2016 indicated an accident rate of 2.1 accidents per million departures, which is the lowest recorded. When accidents or incidents do occur, more often than not they are due to errors made by humans (Civil Aviation Authority [CAA], 2013). Of these, many have, at least in part, been a result of less than optimal Decision-making. Pilots make decisions in an operational environment mostly under time pressure. An example of that is of a lost pilot. In addition to keeping minimum safe altitude and monitoring to keep a safe flight, with the passage of time a pilot is under duress as his chances of an incident or accident-free flight are decreasing (Gilbey & Hill, 2012). They are bombarded with a lot of information. As a result, pilots may process only a small part of the information relevant to their situation.

Arguably, the most notable example of an accident in recent times, which was of a complex nature, is that of Qantas QF32 departing from Singapore in November 2010. On a climb, passing 7000 feet, the A380 experienced uncontained engine 2 failure. The debris impacted the aircraft resulting in significant structural and systems damage. The flight crew managed the situation and, returned to Singapore after having completed the required actions for the multitude of system failures. The crew were faced with a situation that they were not trained

for or had experienced before. Australian Transport Safety Bureau (ATSB, 2010) noted that the flight and cabin crew managed the complex event as a competent team. ATSB (2010) noted positively the decision of flight deck crew in not evacuating after landing and choosing to perform a precautionary disembarkation via the stairs, after assessing the risks and threats associated with the action. Arguably, it appears to be a case of effective Decision-making and crew resource management with crew managing a multitude of failures before safely returning the aircraft and landing at Changi airport without any injuries to the crew and passengers (ATSB, 2010).

In another incident, in 1989, British Midland flight 92 from Heathrow to Belfast, climbing out of altitude 28,300 feet, felt moderate to severe vibrations due to engine no.1 stall, accompanied by a smell of fire in the cockpit. The aircraft was shuddering with vibration and ambient noise level was high. There was no indication of an engine fire on aircraft systems. Crew needed to formulate a plan to deal with noise, shuddering and the vibration, without a clear indication of fire. The crew was never exposed to this type of failure before. The investigation further highlighted that the essence of pilots task to demonstrate flexibility and Decision-making potential to bear on situations that cannot be anticipated is critical (Air Accidents Investigation Branch [AAIB],1990). This example demonstrates that bad Decision-making could have consequences as catastrophic as this one.

A considerable body of research has attempted to understand how decisions are made. Most of this research, if not all, has found its way into the aviation domain as best methods and practices. The Federal Aviation Administration (FAA) recognized decision-making as a critical component of safety in accident avoidance, based on accident analysis by the National Transportation Safety Bureau (NTSB, 1994). As a result, the FAA had embarked on decision-making training for pilots in its efforts to mitigate the decision-making errors (FAA, 1991).

The National Transportation Safety Board (NTSB, 1994) indicated that 25 out of 37 accident analysis in aviation pointed towards tactical decision errors. Orasanu and Martin (1998) examined the NTSB (1994) accident analysis and hypothesized four possible causal factors attributable to how a human being makes decisions. The four factors being under estimation of risk, conflict of goals, the ambiguity of cues leading to a situation not being recognized, and lastly, consequences were not anticipated or evaluated. The question arises as to how the crew

can be encouraged to appreciate the above four factors to improve their decision-making. The research questions in this thesis attempt to provide answers to the above four factors.

1.2. Importance of Decision-Making

Commercial airline pilots have an enormous task of operating in a dynamic environment and remain safe and ensure economical operations. On a day to day basis, pilots face the need to balance profitability for the employer with safety (Jensen & Adrion, 1988). Jensen (1982) noted in a review of 361 general aviation accidents that 186 accidents were fatal. Out of the 186 fatal accidents, 158 were due to pilot error and faulty decision-making. Many decisions that crew make while flying can affect the lives of hundreds of people and have far-reaching consequences (Skybrary, 2010). The FAA (2014) estimated that approximately 80% of all aviation accidents are related to human factors.

A good pilot judgment or decision-making had long been recognized as critical not only for the safe operation of aircraft, but accident avoidance as well. It is argued that understanding of decision-making and human factors, could potentially enhance the process to decrease the probability of human error and increase the probability of a safe flight. Importance of tackling the decision-making errors by the pilots had become the center of airline industry attention. Industry and the FAA (1991) drive to reduce the accidents caused by human factors led to supporting Aeronautical Decision-Making (ADM) to facilitate crew cooperation and help improve decision-making.

In 2016, a high profile accident attributable to impaired decision-making and human factors was that of charter flight carrying the football team of Chapecoense, Brazil (Chandler, 2017). A poor decision made by the flight crew to continue the flight on extremely limited fuel despite being aware of the low fuel levels aboard the aircraft, is cited by the accident report (Accident and Incident Investigation Group [GRIAA], 2017). Numerous decision-making errors from the start of the flight leading up to the crash is a reminder that decision-making remains after so many years of aviation a crucial factor in many accidents. Another instance is that of US Airways 1549 ditching into Hudson river in 2009 after encountering dual engine failure shortly

after takeoff due to a bird strike. It is another case of complex failure which required exceptional skills. The NTSB (2010a) attributed the survivability of the accident to the decision-making of the flight crew members under time pressure and crew resource management during the accident sequence. Apart from the outcome and the quality of the decision-making, the above two accidents are different on a further dimension, that is, the crew of Chapecoense accident not being under time pressure, whereas the Hudson crew definitely was.

1.3. Time Pressure

Time available not being a factor, the crew would generally resort to decision-making process by generating all options available and assessing them thoroughly before choosing an option (Civil Aviation Publication 737 [CAP 737], 2014). Choosing an option is based on facts and logic, and the decision can be altered, adjusted, or changed as and when new information comes to the fore (FAA, 2014).

The dynamics of human performance seem to alter or change a lot when the decision maker is subjected to time pressure. Extensive research exists on the effects of time pressure on decision-making in aviation and in other fields (Jensen & Adrion, 1988). Subject to time pressure, a crew decision in aviation is of great interest as many are safety-critical decisions. Crew tends to carry out what is termed as intuitive decision-making when faced with or perceive time pressure. Under time pressure, it is expected that crew work towards a suitable solution, whereas with no time pressure, an optimal solution is aimed for (Tversky, 1972).

It is suggested that experienced crew working under time pressure may rely upon previously known occurrences or events. An attempt to connect between what is known or experienced in the past will be made with the problem at hand. That is the reason why experienced or experts strategized to make quick decisions in emergency situations under time pressure (Klein, 1993). An example is that of the crew under emergency situation recalling the procedures from their previous flown aircraft type, as they relate to their previous experience.

When faced with no clarity on a problem, decision-making becomes difficult. Added time pressure to the situation requires exceptional and creative problem-solving. Here, just

diagnosing the situation is not enough, a solution must be invented that will satisfy the goal. An example of creative problem solving and decision-making was demonstrated on the Qantas accident QF32. It was a complex failure resulting from a ruptured engine and resulting in many system failures. The crew did not have a single defined checklist to follow. Crew together had to use all resources to come up with exceptional decisions and problem solving (ATSB, 2010).

1.4. Research Problem

Decision-making has figured predominantly as a causal factor in aviation accidents and incidents in the past. More than eighty percent of accidents are due to human factors (FAA, 2014). Furthermore, Diehl (1991, as cited in Wen Chin Li, 2011) concluded that decision errors contributed to 56% of airline accidents. 51 accidents analyzed using Human Factors Analysis and Classification observed that 68% of accidents were due to decision error (Wen Chin Li, 2011). Decision-making errors again in an airline context could be influenced by time pressure, experience, and position held by the crew (Kennedy et al., 2010). It is argued that there is a dearth of information available on Decision-making errors when aircrew are not involved in an accident or an incident. It is proposed to study the problem of decision-making by pilots under the influence of time pressure by comparing various experience levels and position. It could be of interest also to ascertain the confidence levels of various groups on decisions made in the study.

Pilots under time pressure when presented with a problem, spent minimum resources consistent in arriving at an adequate solution, instead of trying for an optimal solution (Zsombok & Klein, 1997; Allnut, 1997). Experience, in particular, seemed to influence the above behavior (Kennedy et al., 2010). Would it mean that less experienced pilots would exhibit behavior contrary to the experienced pilots? Allnut (1987) found that pilots simplify the task under time pressure. It would be pertinent to research into how pilots arrive at an adequate solution to a problem utilizing minimum resources under time pressure.

One explanation of how pilots process information and arrive at decisions under time pressure, is explained by Hammond et al., (1997). The Continuum Figure 1 indicates how decision-making changes from rational decisions on the left to intuitive decisions on the right, according to time available. Several studies (Allnut, 1997; Klein, 1993; Zsombok & Klein, 1997) suggest that people tend to shorten decisions whenever possible.



Figure 1. Simple Continuum for Decision-Making types (CAP 737)

On the extreme left of the above continuum, time available is maximum, whereas, on the extreme right-hand side of the scale, time available is limited. Considering the analysis by the NTSB (1994) had indicated decision-making errors impact safety, it is essential to explore how time influences decisions and the ability to solve a problem. Whether the experience factor helps in improving decision-making or not, could be further explored.

To test the interaction between time and experience factor and effect on decision-making, a series of problem-solving scenarios may be presented to the participants. One-half of participants would be investigated under no time pressure, whereas the other half would be subjected to time pressure. The extant theories of quick decision-making under time constraints (Klein, 1993) and decision-making continuum (Hammond et al., 1997) will provide a framework to guide the current research.

The research found that prolonged stress may also influence decision-making as it affects cognition (Klein, 1993). Pilots tend to take the easy way out by oversimplifying the problem and ignoring crucial relevant information (Rash & Manning, 2009). Studies (Christensen & Szalanski, 1980; Hogarth, 1983; MacGregor, 1993) on time stress argued that people react differently to time stress. Some may do well under time pressure as opposed to without any time pressure, whereas it could be vice versa for others. It would be pertinent to explore the influence of stress, in the form of time pressure, on decision-making of pilots in solving a problem.

The FAA (2014) research indicated that decision-making models provided pilots with a logical way of making decisions. Contradicting research by Jarvis (2007) argued on the strong evidence that using decision aids did not make a positive impact upon general aviation pilots'

decision outcomes. This fact could be explored in this study, as participants include pilots trained in the use of decision-making aids and those who are not trained in using decision-making aids.

In this study, in addition to exploring the time pressure influence on decision-making, insights into post-decisional confidence of pilots would also be examined (Zakay, 1985). It would seek to verify the assertion that when utilizing non-compensatory rules, pilots exhibit greater post-decisional confidence (Billings & Marcus, 1983; Zakay, 1985; Payne, 1976).

Time pressure, ability to process or prioritize information, experience, and stress seem to appear to influence the decision-making capability of the pilots. This research aims to investigate the influence of these factors on decision-making.

1.4.1. Research Questions and Hypotheses

Based on the research problem, the following research questions have been derived. For each research question, the hypothesis (null and experimental) is stated directly below:

Time Pressure

Q1. Does time available influence the decision-making of pilots in solving a problem?

H₀ = Decision-making skills of pilots are not influenced by time available

H₁ = Decision-making skills of pilots are influenced by time available

Experience

Q2. Does experience influence the decision-making of pilots in solving a problem?

H₀ = Decision-making skills of pilots are not influenced by experience

H₂ = Decision-making skills of pilots are influenced by experience

Decision-Making Knowledge

Q3. Is decision-making knowledge influenced by crew position?

H_0 = Decision-making knowledge of pilots is not influenced by crew position

H_3 = Decision-making knowledge of pilots is influenced by crew position

Decision-Making

Q4. Is decision-making by pilots in solving a problem influenced by crew position?

H_0 = Decision-making skills of pilots in solving a problem are not influenced by crew position

H_4 = Decision-making skills of pilots in solving a problem are influenced by crew position

Decision-Making Strategy

Q5. Does decision-making model influence the decision-making of pilots in solving a problem?

H_0 = Decision-making skills of pilots are not influenced by decision-making model

H_5 = Decision-making skills of pilots are influenced by decision-making model

Post Decisional Confidence

Q6. Is Post Decisional Confidence greater when under time pressure as compared to no time pressure?

H_0 = Post Decisional Confidence of pilots is not greater when under time pressure as compared to no time pressure

H_6 = Post Decisional Confidence of pilots is greater when under time pressure as compared to no time pressure

Post Decisional Safety

Q7. Is Post Decisional Safety outcome perceived to be greater when under time pressure as compared to no time pressure?

H_0 = Post Decisional Safety outcome perception is not greater when under time pressure as compared to no time pressure

H_7 = Post Decisional Safety outcome perception is greater when under time pressure as compared to no time pressure

1.5. The contribution of the thesis

This thesis aims to contribute to the body of research related to pilot decision-making, the effect of time, stress, experience, and cognition on decision-making. It also contributes to studying the post-decisional confidence of the pilots after having made a decision. Besides, this thesis is of the value to the pilot community, and airline training in particular. The thesis survey had vignettes covered for in-flight situations requiring the participants to indicate their choice selection. Some of the participants were subjected to time pressure and others under no time stipulation. The information presented on the survey vignettes consist of a mixed difficulty and the problem presented may appear to be straightforward on end of the scale to being vague on the other end. It is the first survey to have studied the decision-making by pilots under time pressure who belonged to airlines which had adopted decision-making model and which had not.

1.6. Structure of the thesis

This thesis is presented in six chapters. Chapter one provided an introductory overview of influence of time pressure on decision-making. It continues detailing the importance of decision-making in general and aviation in particular. It next introduces the time pressure aspect and discusses the impact of airline training in decision-making. It then states the research problem outline. Finally, the significance of the thesis is highlighted before concluding with the structure of the thesis.

Chapter two provided the theoretical background and literature review of this thesis. This

includes general information about the theoretical background and also a review of literature about cognition, human factors in aviation, decision-making, decision-making under time pressure, regulatory literature, and training literature on decision-making from various perspectives. This chapter also included a formal statement of the hypotheses being investigated in this research.

Chapter three includes the methods and procedures used to conduct this research.

Chapter four presents the results of the research. The results presented in Chapter four are discussed in Chapter five. Chapter five also discusses the ideas for further research.

Chapter six concludes the thesis and presents recommendations and implications derived from the discussion.

CHAPTER TWO

Literature Review

2.1. Background

A great deal of research has been undertaken on decision-making under time pressure. This research has been undertaken in settings such as aviation, medicine, technology, management, psychology, and finance (Charles & Whelan, 1997; Zakay & Wooler, 1984; Tsiga et al., 2013; Eisenhardt, 1989). Several studies (Paolo & Gioia, 2016; Elgin & Thomas, 2010) have addressed the effect of time pressure on pilots and on their decision-making. Considerable research exists in cognition in trying to understand how decisions are made under a set of circumstances. Some of this research has found its way into the aviation domain as best methods and practices. Research also was focused for over thirty years on the aspects of sound pilot judgment and the decision-making. The Federal Aviation Administration (FAA) has recognized decision-making as the critical component of safety in accident avoidance. Increased flight accidents in the 80's, and subsequent research into the area of decision-making prompted the FAA to address the aspect of training the pilots in decision-making. As a result of this research, the FAA Advisory Circular (AC), 60-22 (FAA,1991a) came into being.

Cognition, it is argued by Klein and Orasanu (1997) could be influenced by stress and affect decision-making, and hence relevant literature is reviewed. Understanding how information is processed by aircrew is essential. Learning how heuristics are utilized to better decision-making by managing information processing in a timely manner is critical (Wiggins & Bollwerk, 2006). The paucity of time to make decisions is better understood in a review of Hammond's Continuum theory. Experienced decision makers and pilots, it is argued exhibit cognitive bias in arriving at decisions under time pressure. Recognition-primed Decision-making model is next studied. The aviation industry-initiated tools like decision-making models to help improve decision-making (Klein et al.,1993; FAA, 2014). Classic decision-making and naturalistic decision-making are reviewed next. The common denominator in influencing decision-making appears to be time, which is further reviewed in the literature

discussion. Finally, it would help if the decision makers could be trained to handle the pressure of time effectively and develop strategies. Hence, lastly, a review of the aspects of training in decision-making is discussed.

2.2. Aviation Literature

2.2.1. Cognition and Decision-making

Decision-making is a cognitive process. The limitations of the cognitive capacity come in the way. High levels of time pressure and stress can lead to perceptual narrowing and thus a reduced utilization of available cues, decreased vigilance, and reduction in working memory capacity (Klein,1997; Orasanu, 1997; Orasanu & Fischer,1997; Stokes, Barnett, & Wickens,1987). This is evident as people often try to shorten the decision-making process whenever possible (Simon,1957 in Civil Aviation Publication 737 [CAP 737], 2014) and more so with time restrictions for decision-making (Payne et al. 1988, in Kerstholt,1994).

This literature review in trying to address the question whether time pressure changes decision strategies, reviewed key accident analysis and models proposed by researchers. In an analysis of 37 aircraft accidents between 1978 and 1990, in which flight crew behavior contributed to the accident, the National Transportation Safety Board (NTSB, 1994) found that 25 incidents and accidents were involved in what the Board considered “tactical decision errors.” While flight crew makes decisions all the time, the decisions that get the maximum attention are those that result in disasters. A notable example is that of a crash after departure out of Washington National Airport (NTSB, 1982). The crew decided to take off with snow/ice on the airfoil surfaces of the aircraft.

Further, Captain's failure to reject the takeoff during the early stage upon recognition of erroneous engine instrument readings contributed to the accident. Another significant disaster was that of a KLM airlines aircraft at Tenerife, Canary Islands taking off without being sure about runway being clear off traffic (Dutch Aviation Accident Inquiry Board, 1979). Aircrew when faced with a deluge of information to process under time constraints, often have to resort to using heuristics or ‘rules of thumb’ while making decisions (Reason, 1986). The constraints of information processing and use of heuristics by a human mind, could be of interest to the

study as we set out to understand the decision-making of aircrew with and without time pressure. Decision-making process consumes mental and attention resources. The impact of limited resources over performance can be overwhelming. One notable reason for mental resources reduction due to time stress is the information-processing overload caused by the need to process large amount in less time (Reason, 1998).

Time constraint, it can be argued evokes hierarchy of responses from decision makers. Payne et al. (1993) model emphasized hierarchy of responses to time pressure. It advocated that decision makers at first level will respond by merely working faster. If that does not suffice, next they try to focus on the subset of the information. Finally, they proposed that decision makers shift to strategies that are qualitative, and not just quantitatively different.

Understanding how aircrew makes decisions is complex. The decisions more often could be influenced by environmental conditions and structure of the decision task itself. Even the moods and emotions of the decision makers are purported to have a profound influence on cognitive processes (Clore, Schwartz, & Conway, 1994). Information that is congruent with current feelings is more easily recalled than when it is incongruent (Bower, 1981; Isen, Shalke, Clark, & Karp, 1978, as cited in Schwartz, 2000). Schwartz and Clore (1988) impressed upon the fact that since it is difficult to distinguish one's pre-existing feelings from one's response to the target at hand, individuals may evaluate about any target more positively when they are in a happy mood rather than in sad mood. Thus, decision-making could be influenced by mood-congruent recall and the use of one's feelings as a basis of judgment (Schwartz, 2000).

Johnson and Tversky (1983) supported the mood assertion by adding that individuals in a happy mood tend to overestimate the likelihood of positive events occurring. Similarly, the individuals underestimated the likelihood of negative outcomes and events. For the individuals in a sad mood the reverse was predicted to be true. The processing style is dependent upon an individual's state of mind, whether it is in a positive or negative state (Schwartz, 2000).

Simon (1957, as cited in CAP 737, 2014) uses the term 'bounded rationality' to suggest that humans do not have the 'mental capacity' to make perfectly rational decisions. Human

cognition appears to use various mechanisms and shortcut that do not fit the rational model (Kahneman & Tversky,1979). Human mind uses shortcuts all the time, and in an aviation training environment, it is important for the trainers to understand why the crew did what they did (CAP 737, 2014).

A pilot's skill or coping ability lies in simplifying the complex task by dealing correctly in a timely manner with the critical information. Failure to do so may result in either error or possibly an accident. This is due to pilots processing only a small part of the input when bombarded with a lot of information (Allnut, 1987). Wickens (1984) and Allnut (1987) studied how information is chosen to be processed to meaningful percepts by pilots. The stimulus it is believed first falls within the narrow range of pilots' senses. Then after sensation comes perception. The stimulus they conclude, influences the very active mind, which is rapidly converted into a meaningful percept. The human being then attends selectively to only a few of these precepts.

The human mind processes varying amounts of information and accords varying level of attention to each one of them (Craik & Lockart, 1972). This research is supported by James (1980) who explains it regarding low level and high-level processing. Low-level processing is where one appears to be processing very large amounts of information easily, very rapidly and in parallel. Higher level processing according to James (1980) is the subject of conscious attention and in which people process information sequentially and comparatively slowly. The higher level of processing, according to James (1980) is a very small but essential part of people's cognitive processing using this mechanism. Failure of the low-level mechanism gives rise to slips and failure of the higher-level one to mistakes. Body and speech mechanisms are communicated after percepts and memories are compared and decisions made. Finally, the feedback loops complete this hugely complex and highly sophisticated system. Stressors which are hidden like inadequate nutrition, exercise, medication, dehydration, etc. might render the pilots unable to respond in an emergency (FAA, 1997).

Janis and Mann (1980) argue that time constraints induce stress states. Psychological stress is a mediator between the shortage of time and decision-making behaviour (Mano,1992). Pilots may be unable to respond with the necessary reaction time, hand-eye coordination, communication skills or decision-making ability (Rash & Manning, 2009). It is argued that

although there is lot of research carried out in aviation and other domains on the effect of stress on performance, it may be challenging to pinpoint exactly as to which stressors could have potentially influenced the decision-making ability in each case. The next section discusses the effect of stress on decision-making.

2.2.2. Stress and Decision-Making

Judgment and Decision-Making under stress by Kathleen and Charles (2003) ignited a discussion on what factors influence a person's ability to make good decisions in an emergency situation. What influence would stress play in decision-making? Decision-making during an emergency requires processing of massive amounts of information under time constraints. While trying to understand the definition of stress, they take cue for their analysis from stress definition by Salas et.al (1996, p.6), which stated "stress is a process by which certain work demands evoke an appraisal process in which perceived demands exceed resources and result in undesirable physiological, emotional, cognitive and social changes". Demand exceeds resources, is the cue that Kathleen and Charles (2003) pick to analyze the numerous sources from which these phenomena could result. They picked the factors of individual perception, training, and experience. While the literature in this area is limited and not conclusive, the relationship between stress, judgment and decision-making remains relatively unexplored (Hammond & Gillis,1993).

The relationship between judgment and stress drew the attention of US Congress in 1988 to address the compensation for Iran Air flight 655 shot down by the American cruiser Vincennes over Persian Gulf (Hammond, 1988). Furthering the argument made by Gillis (1993), the literature emphasized that it is the perceived experience of distress that leads to problems in judgment. It goes on to suggest that stressful circumstances do not automatically lead to problems in judgment. According to Poulton (1976), stress can lead to improved performance and also performance degradation. The Figure 1, from Yerkes and Dodson (1908), provides an effective illustration of an athlete's performance. It illustrates an optimum athlete performance when subject to an optimal stress level. If overstressed, the performance declines as the body moves towards exhaustion. If the stress level is very low also the performance is not enhanced.

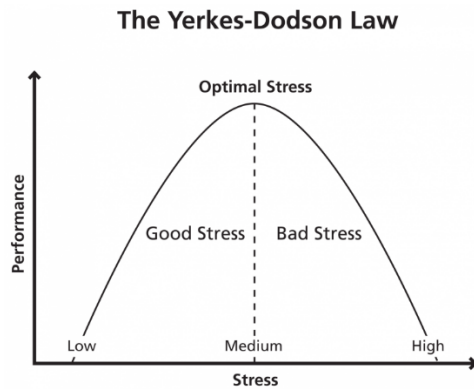


Figure 2. Illustration of performance against varying stress levels.

The effect of stress restricting cue sampling, decreasing vigilance, reducing working capacity memory, premature closure in evaluating alternative options, resulting in task shedding is reiterated by Kontogiannis and Kossiavelou (1999). Serfaty and Entin (1993) studied military commanders and noted that teams displaying superior performance had distinct critical characteristics. They found high-performance commanders extremely adaptive to varying demands. They could maintain performance using just one-third of the time usually available to make decisions. The mode of communication change was noted during the study. As the time pressure increased, the military commanders stopped waiting for explicit requests in communication from commanders, instead provided commanders with the information they implicitly determined would be useful. The authors suggested that changes from 'explicit' to 'implicit' communication can help teams maintain performance under time pressure.

Influence of stress on cognition and ultimately decision-making was studied by Rash and Manning (2009). That the individuals tend to ignore important information under stress is documented by accident at Everglades (NTSB, 1997). The Everglades accident report (NTSB, 1997) findings point towards entire aircrew having suffered from stress-related perceptual tunneling became focused on single stimuli, the landing gear indication light. As a result, important and pertinent information and tasks were neglected resulting in controlled flight into terrain accident. It is imperative that to control stress, and there is a need to identify and manage potential stressors. What all stressors does one need to identify to be able to manage stress? Stressors according to Rash and Manning (2009) are classified as external and internal and indicated in Figure 3. The potential role of external psychosocial stressors such as low job satisfaction, family conflicts, spousal

conflicts, etc. may not have been effectively captured. Environmental factors such as say high noise level, humidity, extreme heat or cold could all influence decision-making.

Classifying Stressors			
External		Internal	
Environmental	Psychosocial	Physiological	Cognitive
Poor flight conditions	Workplace conflicts	Poor diet(Nutrition)	Lack of information
Extreme heat or cold	Family conflicts	Tobacco	Information overload
High noise level	Insufficient flight time	Muscular fatigue	Mental fatigue
Excessive vibration	Low job satisfaction	Sleep deprivation	Fear
Altitude effects	Feeling of lack of support	Alcohol	Feeling of helplessness
Crowded space	Lack of control	High Blood pressure	Boredom
Air pollution	Spousal conflict	Prescription or over counter medications	High workload
Humidity Extremes	Family illness or death	Caffeine	
	Unrealistic expectations	Decreased vision	
	Financial problems	Hearing loss	
	Loneliness	Diseases	
	Devalued self-worth	Hunger	
		Thirst(Dehydration)	
Source: Rash and Manning (2009)			

Figure 3: Classification of External and Internal Stressors.

It is argued that hidden stressors like inadequate nutrition, exercise, medication, dehydration, etc. might render the pilots unable to respond in an emergency. While some stressors may be well known to the pilots, some may go unrecognized. How would one be able to cope with stressors? What tools could one use to manage stressors? One such tool is provided by the regulatory body, the FAA (2009) who has developed a checklist called “IMSAFE” for pilots to evaluate their readiness for flights. This checklist as illustrated below in Figure 4 presents the hidden stressors in the form of an easy to use acronym “IMSAFE” by the crew (FAA, 2009).

I'M SAFE Checklist	
Illness	Do I have symptoms of an illness?
Medication	Have I been taking prescription or over-the-counter drugs?
Stress	Am I under psychological pressure from the job?
Alcohol	Have I been drinking within eight hours? Within 24 hours?
Fatigue	Am I tired and not adequately rested?
Eating	Have I eaten enough of the proper foods to keep adequately nourished during the entire flight?
Source: U.S. Federal Aviation Administration, Clarence E. Rash and Sharon D. Manning (2009)	

Figure 4: IMSAFE Checklist for the crew.

It would also be of interest to this study to understand how people react when exposed to stressors. Transaction model of Stress by Lazarus and Folkman (1984) aims to explain stress and how people react differently when exposed to a stressor. The model as depicted below in Figure 5 suggests that upon facing a stressor, the first thing one resorts to is appraise the situation. This primary appraisal as per the model is to determine the level of danger, potential loss, discomfort or pain, and a certain amount of work required to handle the situation. If no threat is perceived, no stress is felt. In case of a threat perception, secondary appraisal process begins.

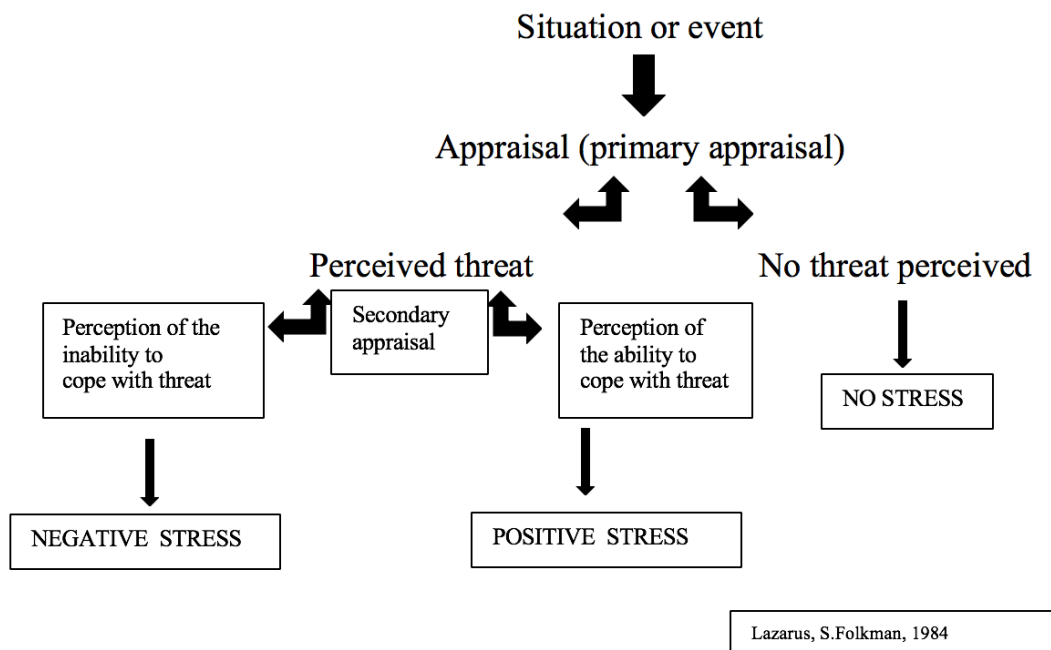


Figure 5. Transaction Model of Stress-Lazarus and Folkman (1984).

The Everglades accident report (NTSB, 1997), in addition to attributing stress being a causal factor, also noted the impact of important and pertinent information and tasks being neglected as a causal factor. How could an experienced crew in Everglades accident (NTSB, 1997) utilize their skills in managing tasks and address pertinent information? Next heuristic-based approach will be discussed in trying to understand how an experienced crew handles information and tasks under time pressure.

2.2.3. Heuristic-Based Approach

Wiggins and Bollwerk (2006) studied the heuristic- based approach and researched the impact of the acquisition of task-related information on the selection of an optimal alternative during simulated in-flight Decision-making. Wiggins and Bollwerk (2006) found that in arriving at a decision, the decision maker acquires information, examines and acts upon it, based on the demands of the task, utilizing his knowledge and experience. It required optimal and timely encoding of information, optimal and timely recall of information from memory, integrate the information acquired to formulate a mental representation of the situation, and finally develop and implement an appropriate response. The fact that this would depend upon the individual decision maker and the features associated with the task was noted by Wiggins and Bollwerk (2006).

The efficiency of the process relates to the time taken to acquire and process the information necessary to achieve an optimal outcome. The accuracy and efficiency of information processing by an individual would depend upon the capacity to acquire, encode, and process information (Ackerman & Cianciolo, 2002). This capacity could have been enhanced through task-oriented experiences (Cellier, Eyrolle, & Marine, 1997). Supporting this assertion is Wiggins and O'Hare (2003) who found that experienced operators utilized their skills to identify relevant cues from an otherwise cluttered environment, thereby reducing the demands on information processing. Conversely, for less experienced operators, an increase in cognitive demands are typically associated with a reduction in performance.

Information acquisition and pilot performance were investigated by Prince, Härtel, and Salas (1993). Performance of experienced and inexperienced flight crews was compared during two simulated flights. Prince et al. (1993) called it adaptive decision-making wherein flights

were designed to provide the crew with three decision points. The videotapes of flights were used to assess the pilot performance. The results among inexperienced crew indicated that at least two of the problems presented were approached using a consistent process, such that rapid problem in one is associated with a rapid problem in another. A diverse and variable pattern of behaviour was noticed with an experienced crew, who utilized idiosyncratic strategies to respond to the characteristics associated with the task. Prince et al. (1993) concluded that the differences between the decision heuristics employed by experienced and inexperienced pilots reflected the extent to which experience within the operational environment can alter the nature of the decision-making process. The acquisition of experience appears to be characterized by the ability to adapt or manipulate previously acquired knowledge to solve novel problems (Dreyfus & Dreyfus, 2009; Anderson, 1993). Patel and Groen (1991) attributing the ability to adapt to novel problems by experienced operators to have the capacity to process and respond to task-related information faster than inexperienced operators. Andrew (1993) referred to this capacity to process and respond as the product of automatization, in which conditions and associated actions form self-contained units in long-term memory. Klein (1989) argued that the speed with which experts respond is attributable to the immediate and spontaneous recognition of task-related cues being familiar and to the activation of a previous exemplar from long-term memory.

Wiggins and Bollwerk (2006) hypothesized that pilot experience would be associated with the selection of an optimal alternative during the three familiarization scenarios that were studied. However, the results revealed that experience as pilot in command, rather than total experience or recent experience, was positively related to the selection of the optimal alternatives across three scenarios. Active participation as a pilot in command and not total experience by way of simple involvement in a task, is found to be a necessary component for the acquisition of cognitive skills (Barsam & Simutis, 1984; Kashihara, Kinshuk, Oppermann, Rashev, & Simm, 2000). The relative perception of the ease or difficulty associated with one information acquisition strategy over another suggested that there is a relationship between a heuristic-based process of information acquisition and the perceived management of information during a simulated in-flight decision. It could be argued based on finding by Wiggins and Bollwerk (2006) that active and recent task-related experience determines the selection of an optimal outcome during non-time constrained, simulated in-flight decision-making. Presentation of

information using a particular heuristic-based strategy did not determine the selection of an optimal outcome when the time was not a constraint (Wiggins & Bollwerk, 2006). However, it was also clear that there are differences between pilots regarding their preference for a particular heuristic-based strategy. The highest proportion of participants selected the strategy that was least efficient regarding the time taken to acquire the information before the selection of an alternative.

To better understand decision-making, further research with emphasis on the relationship between heuristic-based approaches of information acquisition and decision-making in complex, dynamic environments would help (Wiggins & Bollwerk, 2006). Selection of optimal alternatives upon information acquisition is the key. It is influenced by time constraints and increased workload, especially when the decisions vary from being intuitive to being analytic based on the situation (Hammond et al., 1997). The next section reviews the Hammond's Cognitive Continuum theory.

2.2.4. Hammond's Cognitive Continuum theory

Hammond's Cognitive Continuum theory (Hammond et al., 1997) asserts that decisions vary from being intuitive to being analytic based on the situation. While it states that in intuitive decisions, pattern matching is relied upon, in analytical decisions, people use more thorough evaluation process. Hammond's continuum theory (1997) found decisions to be influenced by the task and task continuum that reflected the nature of cues available to the decision-maker. Hammond asserted that good decisions depend on correspondence between the decision strategy and the task. An analytical strategy to numerical task works well, so does an intuitive strategy to a non-engineered cue pattern.

It is argued that very often flight crew decisions involve choice from among alternatives present in the situation. Faced with an onboard medical emergency, the crew may be required to divert to an airport enroute. However, if the weather is deteriorating at the nearest airfield which is equipped with medical facilities, and the next nearest airport being further an hour way, the choice needs to be made. The crew is expected to weigh in the risks of landing under deteriorating weather versus flying further away with less optimal medical facilities. Strategies used by crews to select from among alternatives vary, but observations to date (Klein, 1993a; Orasanu, 1993) suggest that they do not correspond to a full analytical procedure. A full

analysis would involve evaluation of each possible option in terms of every variable relevant to the decision (e.g. weather, fuel consumption, runway length), and a mathematical formula would be used to combine all the information to yield the optimal choice. They work toward a suitable but not necessarily the best decision in the shortest time, investing the least possible cognitive work. Options often are eliminated from one feature, such as weather, and are out of the running after that, unless no suitable alternative can be found, and the process must be reopened. In fact, crew made decisions most economically, taking short-cuts in this process (Orasanu, 1993).

Research on cognitive bias found experienced decision makers frequently exhibit systematic bias. They appeared to place greater reliance on heuristics to solve problems at hand (Kahnemann, et al., 1982). Klein (1993a) while suggesting that crew do not resort to a full analytical procedure, offered strategies experts resort to, in trying to make fast decisions in highly critical situations. An overview of recognition primed-decision model (RPD) by Klein (1993) explains how experts strategize with respect to decision-making under time stress. It aligns with Threat and Error Management (TEM) framework (Helmreich, 2002) by addressing error detection and correction.

2.2.5. Risk Management and Recognition-Primed Decision (RPD) Model

Klein's Recognition-Primed Decision (RPD) model (Klein, 1993), contributes to Naturalistic Decision-making (NDM) approach especially for decisions to be made under time pressure. Here the schema-based knowledge links the recognizable situation patterns and actions that worked in the past under similar conditions to elicit an effective response for decision-making. In trying to understand schema, literature search yielded the following definition: "In psychology and cognitive science, a schema (plural schemata or schemas) described a pattern of thought or behavior that organizes categories of information and the relationships among them" (Nevid, 2007). RPD model (Klein, 1993) provided the example of experienced firefighters, who did not compare different options in critical situations, but were able to recognize specific patterns and were thus able to react appropriately. In fact, experts evaluate the first option that came to their mind for its feasibility; if the option seems feasible, they choose it, if it did not seem feasible, they rejected this option and evaluated the next option

which came to their mind (Klein, 1999).

Wickens et al. (2013) found that in some situations, experience does not always improve decision quality. Walmsley and Gilbey (2016) attempted to reduce the effect of cognitive biases such as anchoring effect and confirmation bias in their study. Their study was weather-related decision-making such as a VFR flight into IMC. They proposed a debiasing technique, "considering the alternative" to reduce the effect of bias. The findings of their study suggest that the use of debiasing techniques alone to improve pilot's decision-making in deteriorating weather conditions may not be sufficient. In order to assist pilots in structured decision-making (Orasanu, 1995), a prescriptive technique such as FORDEC (facts, options, risks, decide, execute, check) model may be applied (Hoermann, 1995). These analytical models may work well for pilots with no time pressure. With time pressure, RPD models will work better (Simpson, 2001). This is necessarily an elimination by aspects strategy (Tversky, 1972).

A recent example of a procedural management decision was the landing on the Hudson River by a USAir A-320 aircraft after both engines were lost due to bird strikes on takeoff from LaGuardia Airport in New York (NTSB, 2009). Captain Sullenberger initially planned to land at Teterboro Airport in New Jersey after the dual engine loss, but realized they had insufficient altitude to travel the 6 miles; instead, he opted to make a river landing. The cognitive work done for this class of decision is primarily risk assessment. Responses are clearly prescribed and highly procedural once the situation is defined as an emergency. If the risk is judged to be high, then emergency procedures are undertaken. If the risk is not immediately defined as an emergency, then additional energy may be devoted to situation diagnosis (Orasanu & Klein, 1993).

Diagnosis of the problem underlying ambiguous cues can serve two purposes. It can clarify what the problem is so that an appropriate action can be taken, or it can provide information that may be useful for fixing the problem (Orasanu & Klein, 1993). When the workload is relatively low and time is available, the crew may try to diagnose and fix the problem (Hoermann, 1995). However, even if the diagnosis does not lead to fixing the malfunction, it can turn the problem into one with a better-defined response, mostly a recognition-primed

decision (Simpson, 2001). Defining the problem undoubtedly may lead to a more specific response than merely treating it as an emergency (Orasanu & Klein, 1993).

Creative problem-solving is perhaps the most challenging type of decision. In addition to diagnosing the situation, a solution must be invented that will satisfy the goal. Perhaps the most celebrated case of creative problem solving was United Airlines flight 232 (NTSB, 1990) in which the DC10 lost all hydraulic systems due to an explosion in the number two engine. The captain invested considerable energy on situation assessment, determining what capability he had left after the hydraulic failure (Predmore, 1991). The two outboard engines were still running, but no flight controls were operative. Knowing that the only control he had was engine thrust, he and his crew determined that they could use asymmetrical engine thrust to turn the plane and power level to control the altitude (NTSB, 1990).

The experience could be used in decision-making by matching schema (Klein, 1993). When the problem is not very clear, a novel or innovative problem-solving might be attempted. Heuristics if available could be used to solve the problem at hand (Kahnemann, et al., 1982). Orasanu (2010) emphasized the importance of risk perception and risk assessment as essential components of effective decision-making. If the risk perception is judged as high, responses are clearly prescribed and highly procedural. If the risk is not judged high, further diagnosis may be carried out. For this to happen, it takes the form of recognizing the problem, generating options, compares them for various decision dimensions, and choose the best option overall (CAP737, 2014). Next, a review of the decision-making models will be undertaken in trying to understand how they generate options and help in choosing an option to solve the problem at hand.

2.2.6. Classic Decision-Making and Naturalistic Decision-Making

Rational decision-making or classic decision-making is when a person applies reasoning and logic to make the most ideal choice (CAP737, 2014). Rational decision-making is the most obvious choice probably for a crew facing an in-flight diversion decision. The combination of circumstances and options, probably accompanied by various emergencies, are unlikely to be the same as experienced or practiced before by the crew. Hence, it is generally recommended for the crew to consider and discuss the complexity of diverting decisions, time permitting,

rather than merely act upon them intuitively. This would mean a process close to rational decision-making. CAP737 (2014) adds that since circumstances are not ideal in terms of clarity of thought, when crew faces a situation, a decision acronym or aid or model is said to assist. Li and Harris (2006; 2008) found improvement in the quality of pilot's situational assessment and risk management when using aids. The FAA (1991) formalized training programs in decision-making as it recognized decision-making as critical for safe operation of aircraft (FAA, 1991a).

The FAA (2014) provided models of a structured framework for problem-solving and decision-making. They are PAVE (Pilot, Aircraft, Environment, External pressures), CARE (Consequences, Alternatives, Reality, External factors), TEAM (Transfer, Eliminate, Accept, Mitigate), and the DECIDE (Detect, Estimate, Choose a course of action, Identify solutions, Do the necessary actions, and Evaluate the actions) model.

The variables that help provide assistance in organizing the decision process are the Plan, the Plane, the Pilot, the Passengers, and the Programming, labeled as 5P's by the FAA (2014). The FAA AC 60-22 (FAA, 1991a) advocated that the pilots should at least use the 5P's five times before and during the flight. 3P model for decision-making is also advocated by the FAA (2014) to assist in organizing the decision process. 3P model advocated that pilots perceive the given set of circumstances for a flight, process by evaluating their impact on flight safety and perform by implementing the best course of action.

Using this Perceive, Process, Perform and Evaluate method as a continuous model for every aeronautical decision to be made, minimizes threats to safety. PAVE checklist is utilized by pilots to perceive hazards. Next CARE checklist is carried out to identify whether the identified hazards really constitute a risk. TEAM checklist is next carried out to carry out risk assessment of identified hazards as the risk. The DECIDE model provides a continuous loop process that provides a pilot with a logical way of making decisions. This model is utilized extensively by airlines flying multi-crew pilots (FAA, 2014). Another equivalent model is known by the acronym FORDEC (Facts, Options, Risks, Decide, Execute, and Check).

The Figure 6 illustrates the DECIDE model. The DECIDE model is essential in making an ideal choice as it helps in applying reasoning and logic. It also helps when conditions are not

ideal, by providing clarity of thought (FAA, 2014). DECIDE model first utilizes the PAVE for situational assessment before proceeding further as indicated in the Figure 6. After the effect of the decision, there is a loop back to detection phase in starting the decision-making loop all over again.

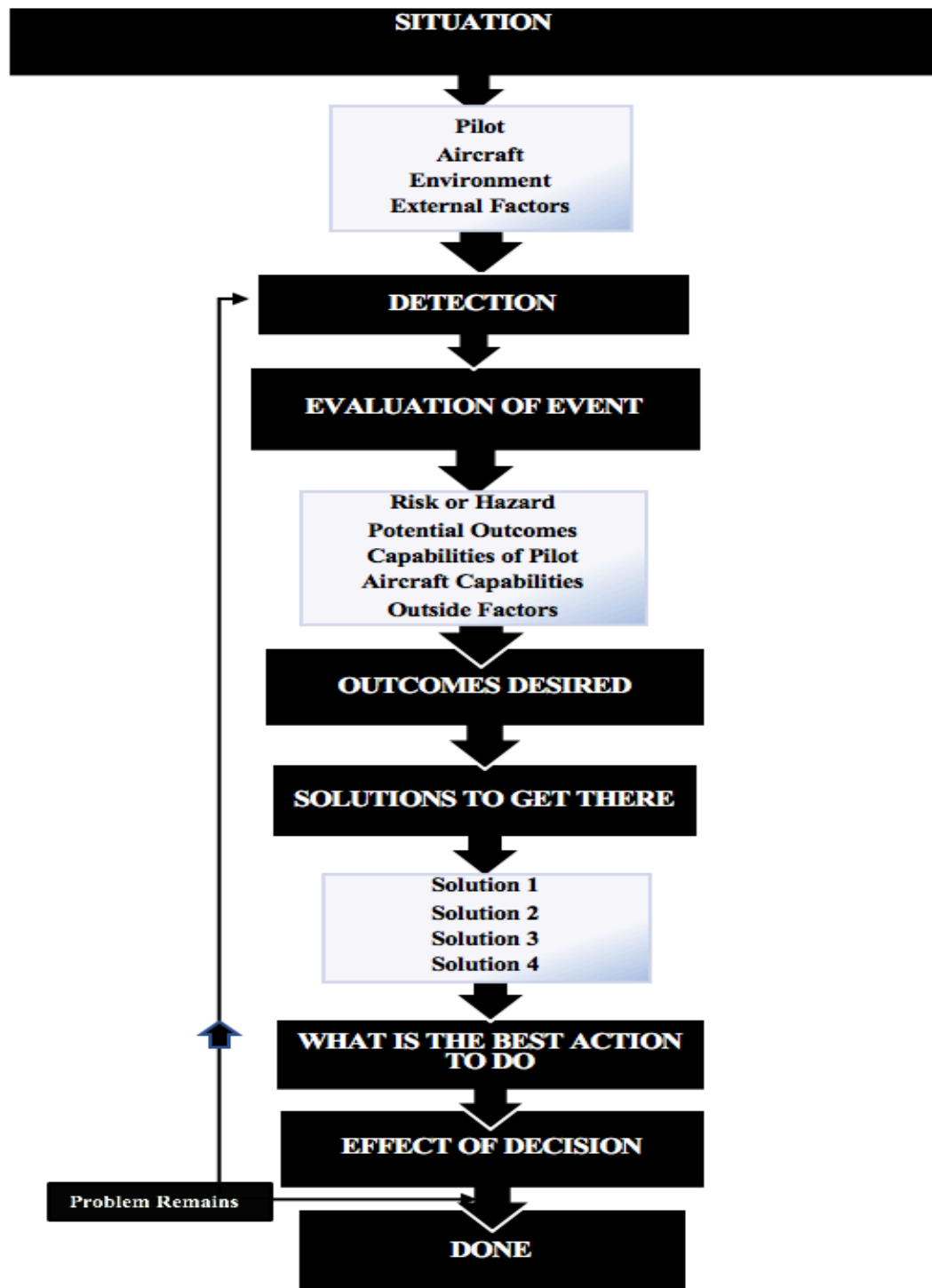


Figure 6. Analytical Decision-making Model (FAA, 2014).

Jarvis (2007) did not find any strong evidence that using decision aids (specifically FORDEC and DECIDE) made a positive impact upon general aviation pilots decision outcomes when continuing towards unplanned IMC conditions. Decision aids are most suitable for novel situations where time and information are clear. However, it may be unsuitable to situations where there is insufficient time to make full use of them. Sometimes, it might make sense to deploy normal short cut tactics or intuitive decision. Hence, the availability of time determines the applicability of rational or acronym-aided decisions or intuitive decisions (Young et al., 2012).

Time criticality is well addressed by British Airways T-DODAR (Time - Diagnose, Options, Decide, Act, Review) decision acronym (CAP737, 2014). It recognizes the fact that the available time may be a significant consideration for the pilots in determining decision-making tactics. The T stands for 'time' and is a reminder to pilots to consider time-criticality and available time before diving into the decision process. In rare time-critical instances, it could also serve the cause of rejecting an aided decision process, when its clear to crew that spending time on the process could worsen the situation (Harris, 2017). Say for example a smoke in the cabin of the aircraft requiring immediate diversion and landing. In other circumstances, it can set boundaries on decision time, say for example in case of deteriorating weather or low fuel condition. The systematic approach provides a logical way of making decisions, but does one have ample time for it? What if one is not able to run the entire loop of decision-making model? Naturalistic Decision-Making (NDM) provides the solution wherein the decision maker sizes up the situation by perceiving hazards (Klein, 1993).

2.2.7. Naturalistic Decision-Making (NDM)

Naturalistic Decision-Making (NDM) places the focus on the decision event, so that the decision makers are able to size up the situation and refresh their situational awareness through feedback, without developing multiple options to compare one another (Zsombok & Klein, 1997). That the ability of the crew to select an option from alternatives available does not correspond to a full analytical procedure, is echoed by Klein (1993) and Orasanu (1993). A full procedure would involve analysis of each possible option regarding every variable or dimension relevant to the decision, be it weather, fuel, runway length and so on. Klein and

Orasanu (1993) further state that crew appears to make decisions most economically, taking short-cuts in the process. Crew work towards a suitable but not necessarily the best decision in the shortest time, investing the least possible cognitive work. Tversky (1972) supported by adding that options were often eliminated by the crew on the basis of one feature, such as say weather or fuel, and were out of the running thereafter. If no suitable alternate could be found, the process was reopened. Illustrated in Figure 7 is the Naturalistic decision-making model (FAA, 2014), wherein the notable difference is the Decision-making being based on previous experience, training and risks perceived. The process as depicted in the Figure 7 starts from perceiving hazards and evaluating risk based on experience and training. The best option is chosen and acted upon. If the resulting outcome is successful, the process ends there. If the outcome was not as desired or successful, then the aircrew reverted back to other options available, and took action to reach a successful outcome.

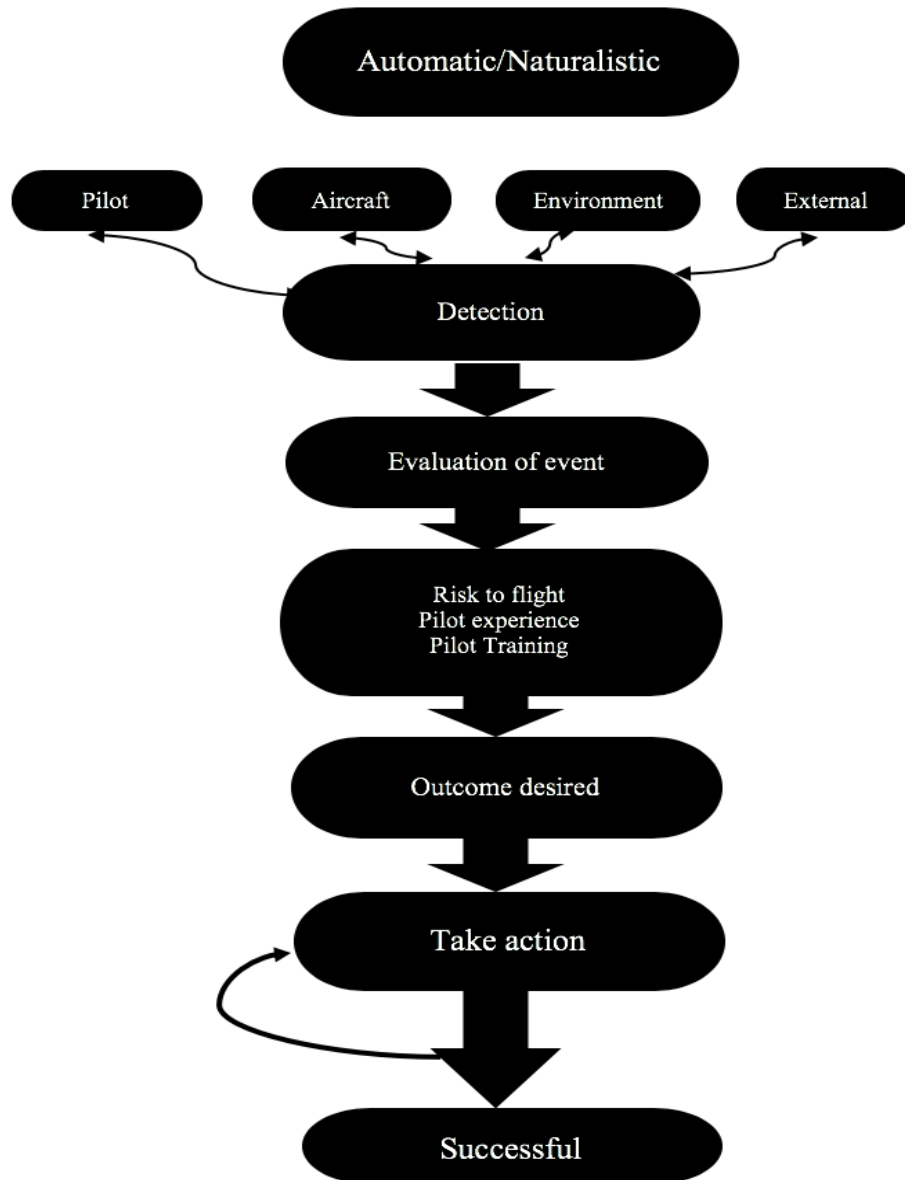


Figure 7. Naturalistic Decision-Making Model (FAA, 2014).

The choice to adopt classic decision-making model or intuitive decision-making is dependent on the crew and the situation they are presented to deal with. Some airlines have adopted decision-making model, and some airlines decided to train crew to make decisions without adopting any decision-making model (Orasanu, 1994).

How do airlines with decision-making model fare as compared to airlines without decision-making model? This could be of interest to this study with participants predominantly from

airline background. However, it is long investigated that the influence of time pressure on individual decisions show that time pressure is detrimental for decision-making quality (Busemeyer & Diederich, 2002; Diederich, 1997; Diederich & Busemeyer, 2003). How does the time pressure influence decision-making? Next, time pressure and its effects on decision-making is reviewed.

2.2.8. Time Pressure

Svenson, Edland, and Karlsson (1985) and Edland (1985) studied the effects of time pressure on judgments of preference. The experience of time pressure and stress was measured in a questionnaire. A subject's task was to judge the attractiveness of a set of student apartments with and without time pressure. The apartments were characterized by their size, standard, and traveling time to the university. The results showed that the negative aspect of the most important attribute, in this case traveling time became much more important for the judgments under time pressure. Thus, the alternatives with poor values on this important attribute became relatively much poorer than under no time pressure. Time pressure seemed to have the effect of both giving one attribute more weight in relation to the others. It also made the alternatives generally less attractive, as compared to judgments under no time pressure. This may parallel the results of Wright (1974) in that decision makers weigh negative consequences more heavily under time pressure. The results may also be related to the Easterbrook (1959) finding of a tendency to focus more on central information and not paying as much attention to less central cues under stress. Will this time pressure affect the performance?

Paolo and Gioia (2016) conducted field study under which they investigated whether and how the time pressure affects performance. It was argued that performance in any activity is likely to be affected by the stress arising from the need to cope with limited time. Paolo and Gioia (2016) study involved real-life situations, students sitting for the final exam to investigate how and to what extent being exposed to time pressure affects individual performance. It also investigated whether there is heterogeneity in the ability to handle time pressure. Paolo and Gioia (2016) found that the negative effect of time pressure results in worsening of the reasoning process. It can also lead to individual tendency to ignore important information and rely on heuristics. Time pressure changed individual attitudes towards risk (Kocher, Pahlke,

&Trautmann, 2013; Bollard, Liu, Nursimulu, Rangel, & Bossaerts, 2007). The reasoning above is supported further by Mosier et al. (2007) who stated that time pressure may make it less likely that individuals will seek out and process all the information and cues required to assess a judgment situation.

Mosier et al. (2007) conducted a study with regional carrier pilots flying automated aircraft utilizing an interactive website to represent the automated cockpit. Operational variables such as time pressure, the source of initial indication problem, and information sources consistency were chosen. It was proposed to study their effects on the coherence of the diagnosis and judgment process. A notable hypothesis of interest to us being that pilots who are under time pressure will take less time, exhibit less thorough information searches, and derive less accurate diagnoses than those who are under no time pressure. Mosier et al. (2007) found the results of the study illustrated the negative impact of common operational variables on information search. It also showed potential negative consequences of incomplete information search regarding diagnosis and decision accuracy. Pilots found the experiment realistic enough to be influenced by the time pressure manipulation. The pilots' comments indicated that they perceived the scenarios as very representative of real operational incidents. Time pressure had a significant effect on time to diagnosis. Pilots who were in the time pressure condition took less time to come to a diagnosis than did those who were not under time pressure, affirming the effectiveness of the time pressure manipulation. Time pressure had a significant negative effect on the number of different pieces of information accessed, and the number of information rechecks (Mosier et al., 2007).

Hammond (2000) suggested that coherent information use is highly susceptible to variables such as time pressure, distraction, and stress. Studies supporting the above information are by Skitka, Mosier, and Bur (2000), who have studied automation bias. In the automation bias study, students who were made accountable for the speed of their response checked less information and made more diagnostic errors than did others. Maule, Hockey, and Bdzola (2000) also found in their experiment that participants making judgments in risk scenarios accessed a smaller proportion of information sources. Further, the participants spent less time looking at information accessed when under deadlines than when no time pressure was placed

on them. These results suggest that time pressure may negatively impact coherence in diagnosis by fostering a curtailed information search and encouraging quick but incomplete processing of information. It may be then expected that pilots will perform less thorough information search when the time is short, than when under no time pressure. Maule et al. (2000) found that the negative effect of time pressure is likely to be the costliest in certain situations. Further, it was found that incongruent information may require extra time to unearth data that is hidden. In such cases with paucity of time, diagnosis is rushed and may not be based on coherent process.

Zakay and Ariely (2001) studied the effect of time pressure on decision-making and decision strategies. It is argued that decision makers apply algorithmic- compensatory strategies under time pressure. However, when faced with time constraints, the decision maker may not be able to complete all the steps or make cognitive errors while following the rules (Ben-Zur & Breznitz, 1981; Payne, et al.,1988). People when unable to cope with time pressure, might respond by trying to work faster, if not successful, they start focusing on a subset of available information. Finally, if that is also not enough, people may change the strategies to non-linear decision strategies (Ben -Zur & Breznitz, 1981; Christensen -Szalanski, Mano, 1992; Wright, 1974; Wright & Weitz,1977). Non-linear thinking is a prized ability of humans that is applied when problems are challenging, and all known solutions have failed to provide an adequate solution. For example, when all available choices are bad choices, settling for a least bad choice occurs (Santos, 2018).

Schutte (2012) studied the challenges and changes the birth of a baby brings about in the family. The research studied parents who experience stress with children having disabilities such as deafness or hard of hearing (Quittner, Steck, & Rouiller, 1991, as cited in Schutte, 2012). Schutte argued that parents face many unfamiliar challenges, especially dealing with a disability, that makes them pressured into highly stressful and crucial decision-making early on in a child's life. Often these challenges are accompanied time pressure. Time is an important environment factor that increases the feeling of psychological stress. Time pressure is common in many settings, especially in situations in which important and complex decisions must be reached in a timely manner (Schutte, 2012). How would this be relevant to aviation decision-making? Aircrew are often faced with unfamiliar challenges such as complex failures, which could put undue stress on them (NTSB, 2010). With the addition of time constraints, further

pressure could be put on decision-making. Example of Air France 447 accident cited amongst many factors, startle effect and theoretical knowledge, which could have potentially increased stress and influenced the decision-making process (Bureau Enquêtes -Accidents [BEA], 2012).

For parents with disabled children, making a decision itself is stressful, and managing a lack of knowledge about choices or the inability to process all available information causes emotional stress (George, 1974, cited in Schutte, 2012). Time pressure may increase this stress because parents feel a strong sense of failure when they cannot process this critical information. Time pressure may also induce feelings of helplessness since fast processing is required. This is likely to cause the decision-maker to ignore specific information that might be important (George, 1974, cited in Schutte, 2012). An example from the aviation domain is the Everglades accident (NTSB, 1997) wherein crew ignored important information while flying into terrain. Miller (1960) echoed a similar view with his model. He hypothesizes that people use three different strategies to handle time pressure. They are filtration, acceleration, and avoidance. When using the filtration strategy, the decision maker processes the important information first and then the other information in order of priority until time runs out. During acceleration, the decision maker processes the information at a faster rate which can lead to misinterpretation of the information (Miller, 1960). The decision-maker tries to avoid the situation during the avoidance strategy. Schutte (2012) found evidence of elevated stress in parents and suggested early intervention strategies to cope with the disability of children that might have helped in managing the parent's stress.

Schutte (2012) reiterated the fact that any decision-making consumes time. Some decisions are done faster and some others with lightning speed. Such decisions by virtue of being habitual or intuitive non-analytical decisions, do not involve extensive information processing (Russo & Shoemaker, 1989). The more a decision is analytic and algorithmic, more time is needed for its utilization (Orasanu, 1995). Many decisions may fall into the category of short duration and intuitive. Example being such as what to wear and eat, buy a house or stocks, and activities that might involve time and labor regarding information processing. In comparing the static and dynamic decision-making, Brehmer (1992) argued that in making a decision, it is not enough to know what should be done, but also when it should be done.

Taking time into account could be either in terms of making an optimal decision or change in decision structure as a function of time. Static decisions on other hand involve no time constraints. Deciding to take a coffee break or buy a lottery ticket are the examples of static decision-making. Example of a dynamic task in study by Klein (1993) is that of a firefighter trying to control a fire, while the context and decision environment is changing with time. Klein (1993) points out to the fact that despite the prominence and importance of dynamic decision-making, most of the research is concentrated on the static decision-making. Edwards, Lindeman, and Phillips (1965) argue that only dynamic decision-making can do justice to the complexity of the real-world situations. The lack of research in dynamic decision-making, it is argued is due to the difficulty of investigating dynamic tasks through the wide space of decision-making and the trajectories that participants may take resulting in lack of control (Kerstolht & Raaijmakers, 1997).

Zakay and Ariely (2001) highlight the importance of time as an important resource in decision-making. Allocation of less time needed for decision-making or as perceived by the decision maker, might cause a feeling of time stress. This, in turn, might harm the optimality of the decision process. An example is that of a time-stressed decision maker making choices. Those choices may not correspond to the predicted outcomes. The decision maker might not choose the alternatives with the highest expected value (Payne, et al., 1988, Payne, Bettman & Johnson, 1993; Zakay & Wooler, 1984). It is essential to understand the influence of time stress in Decision-making. In a real world and in emergency situations, shortage of time is a natural characteristic of the decision environment (Zakay & Wooler, 1984).

Time stress is induced when time available is reduced for making a decision (MacGregor, 1993). People react differently to time stress. Some may do well under time pressure than with no time pressure, whereas it could be vice versa for others (Christensen & Szalanski, 1980; Hogarth, 1983). This is an indicator that the relationship between an objective shortage of time and time stress might be a complex one. It is not limited to direct effects of time stress on decision outcomes. Many investigators have reported the negative effects of time stress on Decision-making (Ben-Zur & Breznitz, 1981; Edland & Svenson, 1993; Janis, 1982; Keinan, 1987; Zakay, 1985; Zakay & Wooler, 1984).

Zakay (1993) suggested that a reduced amount of resources available for decision maker under time limit conditions is caused partly by an automatic allocation of attention resources for monitoring of the time passage itself. An automatic continuous resource demanding process of duration estimation by decision maker starts when time stress is perceived, according to this model. Supportive evidence by Zakay and Wooler (1984) demonstrated that training participants improved their performance under normal conditions. Whereas under time stress, training decreased the decision quality.

Payne et al. (1993) and Johnson and Payne (1985) argued that decision makers when faced with time limits, may be forced to resort to strategies that are less demanding, less time consuming, but also less accurate. Participants in their study according to Payne et al. (1993), appear to select a decision strategy that saved them from a considerable effort at the expense of only a small decline in accuracy. The adaptive process suggested that decision-makers adapt to time pressure in a way that appears to be sensitive to the accuracy of the Decision-making process. Under moderate time pressure, the adaptive model suggested that decision-makers appear to adapt by being more selective in the information they consider. Under severe time pressure, the study suggested that the decision makers shift to strategies that are qualitative, and not quantitatively different. Payne et al. (1993) argued that the utilization of these strategies is a must for decision makers to perform well under time pressures. Could there be any other approach to performing better under time pressure? How could the decision-making process be done better? Can decision-making training help in making better decisions? Next, we delve into decision-making training literature.

2.2.9. Decision-Making Training

In order to understand whether aircrew can be trained in decision-making effectively, a review of Orasanu (1995) was undertaken. The paper addressed the differences in pilot decision-making both under traditional decision-making as well as naturalistic decision-making. The model by Orasanu (1995) analyzed the decision-making by experienced pilots in the complex aviation environment, wherein they were subjected to various conditions and constraints. Here Orasanu (1995) aimed to describe the process by which an expert comes to a decision and the problem structures upon which the decision maker operates. Reference is made to Klein's (1989, 1993) theory of Recognition Primed Decision-Making (RPD) in trying to understand

what drives pilot's decision-making. Recognizing a situation and retrieving an appropriate response to the type of problem will help in evaluating the consequence of taking that action. Decision maker's experience, it is argued influenced the buildup of patterns in memory. These memory patterns, in turn, serve as the basis for the recognition process and to generate a set of actions tied to those conditions. Such a model maps well onto decision-making in the aviation domain, where many decisions are rule-based and highly procedural (Klein, 1993). In aviation, there are many explicit condition-action rules, unlike many other domains where the pairings depend primarily on years of experience in the domain. In aviation the goal is to reduce demands on pilots to think creatively when they are under stress, time is limited, and risk is high, such as during take-off and landing. Because of these conditions, the industry (including operators, manufacturers, and regulators) provides as much explicit guidance for decisions as possible (Klein, 1993).

Earlier decision-making training emphasized the following steps in the decision-making process:

- Define the problem.
- Gather data.
- Generate all possible options.
- Evaluate all the options
- Decide
- Monitor outcomes and critique the decision (Orasanu, 1995).

While this was not a bad model, it lacked in several ways. It was not sensitive to what experts actually do. It did not consider the knowledge and experience of the expert, and this model took too long to arrive at a solution. It was also not sensitive to significant differences in problem situations and focused on an individual decision maker rather than on a crew (Zsombok & Klein, 2014).

Orasanu's (1993) experiment first observed various crew in full flight simulators flying the same scenario, to identify strategies associated with variance in crew performance. Another dimension used was to examine a large number of incident reports submitted to the non-jeopardy Aviation Safety Reporting System (ASRS, 1991). Data was captured covering a broad

spectrum of situations requiring decisions by pilots. This data, however, did not provide leads as to what decision process was followed by the crew. The third approach was to examine a set of accident investigations by the National Transportation Safety Board (NTSB, 1994) which provided accounts of what happened prior to an accident. The NTSB (1994) in these cases also provides causes, contributory factors, as well as in-depth analysis by a group of aviation experts.

Aviation Safety Reporting System (ASRS) analysis according to Orasanu (1993), indicated that decision events differ enormously in what they demand of the crew. The ASRS analysis emphasized on what options and supports exist in procedures and policies for making the decisions, and in features that may make the situation difficult or error-prone. In short, some decisions are highly procedural and are supported by explicit rules. Some of these must be carried out almost reflexively. They typically require quick decision and action in high-risk situations, such as take-off and landing. Other rule-based decisions do not include the elements of time pressure and risk. Rule-based decisions look most like Klein's recognition-primed decisions (1993) and accounted for over half the decisions in the ASRS sample.

Orasanu (1993) based on Klein's model, proposed a two-phase decision-making model. One was situation assessment and the second one was the selection of a response. In practice, these may be iterative processes, because taking action frequently changes the situation, thereby requiring a new decision. Time pressure and risk are two factors that primarily influence the decision strategies (Orasanu, 1993). Time pressure has been found to limit information used in making decisions and to induce shifts in strategies (Orasanu & Strauch, 1994; Stokes, Kemper & Marsh, 1992; Svenson & Edland, 1987). The effect of risk on the pilot judgment has not been empirically investigated. The salience of both dimensions to pilots, however, has been demonstrated by Fischer, Orasanu and Wich (1994).

In examining decision cases that appeared to require considerable effort, two factors that seem to determine the cognitive effort demanded by a decision situation are:

Ambiguity in cues that specify what the problem is increases the level of effort in the Situation Assessment component. Lack of a prescribed response option increases the effort level of the Response Selection component. These two factors are hypothesized to vary independently and

combine to affect the overall amount of work required to cope with a decision situation and the resulting decision strategies (Payne et al.,1993).

The above analysis yielded several implications that differ from more traditional approaches to decision-making training. The important point being that slavish adherence to a process is probably not wise. Also, a common error evident in crew performance in full-mission simulators was an oversimplification of problems, which showed up in an inadequate evaluation of options in choice problems. Crews need to develop evaluation skills that include consideration of constraints, consequences, and broader situational factors (Orasanu, 1995).

Given that naturalistic decisions are embedded in larger ongoing tasks, it is critical that pilots be aware of the need to manage the situation in order to create the possibility of making good decisions (Zsombok & Klein, 2014). This usually means structuring crew workload, prioritizing tasks, and buying time. Strategies such as requesting holding or vectors (fuel permitting), contingency planning, and using low workload periods to prepare for decisions during high workload periods may be resorted to. This may mean having the First officer fly the plane (Orasanu, 1995). This could be of relevance to this study invalidating the strategies discussed ascertain its effect on the results of this study.

Decisions in aviation environments rarely need to be made by a single individual, even if a solo pilot is flying the plane. Ground support is usually available by radio even if co-pilot is not available. It is argued that evaluating resource requirements and capabilities is essential to being able to make a good decision (Zsombok & Klein, 2014). Pilots must learn to ask, 'What do I need?' and 'What do I have?' and then make sure that they have what they need. This is advocated as part of non-technical skills (Skybrary, 2010). In commercial air transports the cabin crew, ATC, dispatchers, and maintenance personnel can all provide the flight crew with additional information, recommendations, and perspectives. Using these resources does not dilute the captain's responsibility for making the decision, instead provides input that can enrich the decision. It is still up to the captain to evaluate the quality of the information or recommendations received. Involving other people inside or outside of the flight deck means being explicit about what the problem is and what is needed, in other words, building a "shared mental model" for the problem (Orasanu, 1995).

Decisions are often made under less than optimal conditions, namely, high risk, time pressure, high workload, and ambiguous conditions. Keeping human learning in mind, prudence demands training under the conditions of actual flight. This is the reason that major airlines are training for crew coordination in full-mission simulators, where the highest degree of realism can be maintained outside of an actual aircraft. Practicing skills in realistic situations is the best insurance against the threat of "inert" knowledge, or knowledge that can be told but not applied (Orasanu,1995).

Two major conclusions can be drawn from naturalistic analysis of decision-making in the aviation domain. First, attention must be paid to developing both the specific content knowledge that experts have so readily available in long-term memory and the strategies for applying that knowledge in making decisions. Second, good decisions are made in well-managed cockpits. Hence it is important to develop the task management and communication strategies that support effective decision-making skills (Orasanu, 1995).

The question of whether decision-making is trainable is well addressed by Federal Aviation Administration (FAA, 2011). Accident analysis in the last few decades as per the FAA (2011), recognizes the fact that aeronautical decision-making (ADM) is critical to the safe operation of aircraft, including accident avoidance. Crew Resource Management (CRM) training for flight crew evolved, as a result, to focus on effective use of all available resources to support and improve decision-making. Research by the FAA (1988) resulted in producing training direction for improving decision-making of pilots by way of training curriculum and regulation.

In investigating the training effectiveness, the FAA (2011) had validated independent studies on pilots receiving training. The results point towards pilots trained in aeronautical decision-making committing fewer in-flight errors than those who had not undergone training. The differences were statistically significant and ranged from about 10 to 50 percent fewer judgment errors. In the operational environment, an operator flying about 400,000 hours annually demonstrated a 54 percent reduction in accident rate after using these materials for recurrent training. Traditionally good judgement and decision-making were considered a natural by-product of experience. Aeronautical Decision Making (ADM) it is believed enhances the process to decrease the probability of human error and increase the probability of a safe flight (FAA, 2011).

Naturalistic or automatic decision-making improves with training and experience, and a pilot will find himself or herself using a combination of decision-making tools that correlate with individual experience and training (FAA, 1988). Another perspective on training is presented by Dolan (2018) in his study of pilots in simulator sessions. Dolan suggested that unpredictable and variable training forces pilot's into making sense of what is happening and helps build better mental models. This way it is expected that the first familiar solution is not chosen.

CHAPTER THREE

Method

3.1.1. Aim

This study aimed to: i) measure the opinions and knowledge of pilots on Decision-Making; ii) test the influence of time pressure on Decision-Making; and iii) investigate whether the position or experience of the participant pilot would be an influencing factor in the pilot's measure of opinion and knowledge in Decision-Making, and on Decision-Making itself.

This section begins by describing the research design and the research approach strategy chosen based on the research problem and the hypotheses. Next, there is a description of the participants in the study. The survey was the instrument utilized to measure the aim of this study, the content of which is discussed in the materials section. Finally, there is the procedures section which discusses the general procedures used during the study.

3.1.2. Design

3.1.2.1. General

The challenge presented during the research design was about choosing an appropriate research paradigm. In order to test the research hypotheses detailed in Chapter 1.4, a brief overview of two main research approaches will be discussed in the following sub-chapters. Further, justification to the choice of research approach to investigate the research hypotheses will be outlined.

3.1.2.2. Research Approach : Qualitative versus Quantitative Approach

Research design, according to Vogt and Johnson (2011, as cited in Collis & Hussey, 2014), is the science and art of planning procedures for conducting studies to obtain most conclusive

findings. The research paradigm is a philosophical framework that guides how research should be conducted. There are two main paradigms, namely: 'positivism' and 'interpretivism' (Collis & Hussey, 2014).

'Positivism' is underpinned by the belief that reality is independent of us and the main aim is to discover theories, based on observation and experiment (empirical research). 'Interpretivism' is underpinned by the belief that social reality is not objective but highly subjective because people's perceptions shape it. Hence, it focuses on inductive process and provides an interpretive understanding of the social phenomena within a particular context (Collis & Hussey, 2014).

3.1.2.3. Qualitative Approach

According to Smith (1983) and Creswell (2014), in interpretivism, the researcher interacts with that being researched because it is impossible to separate what exists in the social world from what is in researcher's mind. So the act of investigating social reality affects it. The hypotheses of interest as outlined in Chapter 1.4 could be investigated through the use of interpretivist paradigm and an ethnography methodology through participant observation (Collis & Hussey, 2014).

The aircrew's decision-making is better ascertained by observing them in their natural setting. The single most advantage of this methodology is the direct observation which aids in understanding and interpretation of the decision-making under time pressure. It is useful in gaining information which otherwise could not have been observed (Denzin & Lincoln, 2011). The practical problem and limitation to this approach are to negotiate access across airlines to observe aircrew. The second significant limitation could arise concerning coping with full-time involvement in observation. Thirdly, the primary issue would be whether the particular setting and airline best reflects the research interests and whether it will be possible to generalize from the findings (Collis & Hussey, 2014). Finally, the hypotheses cannot be observed in a real environment as decision-making under abnormal conditions and failures cannot be simulated. The choice then falls on to observing simulated failures in an approved simulator which could involve practicality and huge costs involved in doing so. Due to the above mentioned potential issues in studying decision-making under time pressure, a different approach was needed in order to test the hypotheses of interest.

3.1.2.4. Quantitative Approach

Knowledge is derived from ‘positive information’ and can be scientifically verified. It is possible to provide logical or mathematical proof for every rationally justifiable assertion (Wallman, 2011). Positivists believe that reality is independent of us and assume the goal of investigating social reality does not affect that reality (Creswell, 2014).

The hypothesis of interest as outlined in Chapter 1.4 could be investigated through the use of a positivist paradigm and an analytical survey methodology. The use of an analytical survey methodology could be appropriate, as this methodology is about determining a relationship between pairs of variables or multiple variables. It is about collecting primary data from a survey of aircrew population with a view to analyzing the data statistically and generalizing the results to a broader aircrew population (Collis & Hussey, 2014). The survey allows the study to explore the decision-making of aircrew under time pressure by collecting information through their responses to questions (Ponto, 2015). Surveys by virtue of being cheap, quick, and versatile are very easy to use in research (Bhattacharjee, 2012). By virtue of not being a direct observation, the demerit of altered behaviour of the subject under observation in a survey is avoided (Cozby & Bates, 2015). The experimental setting, however, has the potential to impact significantly upon the behaviour of participants. It may also reveal some important characteristics that may not otherwise have become apparent (Wiggins & Stevens, 1999). Hence, the positivist paradigm and analytical survey methodology would be appropriate to investigate the hypotheses of interest in this study. This methodology allows for higher sampling as well.

3.1.2.5. Research Strategy

Considering the nature of this study, the positivist paradigm, using an experimental design and survey methodology, has been chosen as being the most appropriate. An experiment was conducted utilizing a survey designed to understand decision-making by pilots with and without time pressure. The experiment was conducted through an online survey and also at airline premises with a hard copy version of the survey. In this study, the use of survey was considered to be the best choice as it is versatile, easy to use (Bhattacharjee, 2012) and can be generalized to a broader population (Collis & Hussey, 2014).

3.1.3. Participants

There were 358 participants in this study who completed the survey, of whom 174 (48.6%) were conducted under no time pressure, and 184 (51.4%) were conducted under time pressure. Participants were airline pilots from 36 airlines around the world, including from the Americas, Africa, Europe, Asia, and the Pacific. The age of the participants is varied and categorized into four categories as illustrated in Table 1. The modal age category was higher than forty-five years (>45yrs). The participants mean experience in flight hours is indicated in Table 2 and Table 3 indicates participants segregated as per position.

Table 1

Participants' age band

Age Band	Participants	
	<i>n</i>	%
<25 years	7	0.8%
25-35 years	100	27.9%
>35-45 years	108	30.2%
>45 years	143	39.9%

Table 2

Participants mean experience in flight hours was as below

Flight Experience <i>hours</i>	Participants	
	<i>n</i>	%
<5000 hours	68	19%
5000<10000 hours	110	30.7%
>10000 hours	176	49.2%

Table 3*Participants' 'ranks' are shown below*

Position	Participants	
	<i>n</i>	%
Line Captain	157	43.9%
Line Co-Pilot	70	19.6%
Training Captain	117	32.7%
Training Co-Pilot	7	2.0%

3.1.3.1. Sample Method and Size

The population of interest for this study was airline pilots primarily, and who are involved in various positions including training. Since it is a specific and defined group, sample size and method could be a challenge and an important factor. Most research involves sampling participants from the population of interest (Cozby & Bates, 2015).

In this study, a non-probability purposive sampling method was chosen. The non-probability sampling method is inexpensive, efficient and convenient was chosen. Due to the nature of this research, purposive sampling was preferred as the population of interest is airline pilots with specific positions involved (Trochim, 2006).

The sample size is key to be able to generalize to a wider population. Based on the response rate of 60% in previous research by Gilbey et al. (2006), it was calculated that to obtain a sample size of 150; it would require to reach out 240 airline pilots. According to CAE pilot forecast (2017), there are currently two hundred and ninety thousand airline pilots worldwide. To be able to generalize the findings to this population of two hundred and ninety thousand airline pilots, the following sample size was determined based on Smith (2018):

Necessary sample size= $(Z\text{-score})^2 C * StdDev * (1-StdDev) / (\text{margin of error})^2$

Confidence level corresponds to Z score and in case of 95% confidence level = 1.96 (Smith, 2018). Therefore, to calculate required sample size to generalize to the entire airline population of 2,90,00 would be $(1.96)^2 * .5(.5) / (.5)(.5) = 384.16$. Hence, 385 respondents are required.

The sample size captured is 358 for this study after targeting 480 pilots for the survey, which is a response rate of 74% (which was significantly greater than the 60% response rate observed in Gilbey, Fifield and Roger's (2006) study on comparative optimism and stress, which the authors noted was particularly good). Ison (2011) found small sample sizes are common in aviation research, reiterating the need either to increase the sample size or increase power by accepting a larger alpha level. Since the sample size of 358 is fairly close to the required ideal sample size of 385 to cover the entire airline population, and being supported by response rate of 74%, it was decided that increasing power may not be required.

3.1.4. Materials

The study adopted a survey/questionnaire methodology to collect empirical data to measure participants' decision-making knowledge and decision-making ability. Based on a literature review, specifically on the influence of time on decision-making, a 31 item questionnaire was designed for use in this study. The overall questionnaire had three sections: Section A, Section B and a short section to capture demographic information.

Section A had 11 items that were designed to elicit information about participants decision-making knowledge. Section B had 20 questions which were designed to assess how participants' might make aviation decisions, using scenarios/vignettes which they were asked to evaluate.

To enable the experimental manipulation, participants were divided into two groups: the control group, who were subjected to no time pressure to complete the questionnaire; and the experimental group, who completed the experimental task under time pressure (participants were subjected to a time limit of 10 minutes to complete all tasks). Demographic information about participants was gathered to ascertain their age, experience, and crew position.

Section A surveyed participants decision-making knowledge. The individual items were each designed to elicit such responses that could be used to quantify participants' knowledge about aviation decision-making. Section A was expected to provide a mean overall score on general knowledge about aviation decision. It consisted of eleven items. The responses for the 11 items in Section A response ranged from strongly disagree, disagree, neither agree nor disagree,

agree, to strongly agree. For statistical analysis purposes, all 11 questions were assigned numerical values of 'strongly disagree' = 1, 'disagree' = 2, 'neither agree nor disagree' = 3, 'agree' = 4, and 'strongly agree' = 5, were assigned to each of the potential responses. Items numbered 4 and 7 were negatively worded statements and were reverse scored on the Likert scale. The score of 3 for an item indicated that decision-making knowledge required in the item was average. A score lower than 3, say, a 2 indicated poor knowledge on decision-making, and a 1, indicated very poor knowledge on decision-making for that particular item. A value of 4 corresponds to good decision-making knowledge for that particular item. A value of 5 is very good decision-making knowledge for that particular item. Likert scale was chosen as it could be used to measure the pilot's decision-making knowledge and find out to what extent they tend to agree or disagree to a particular item (Collis & Hussey, 2014). Hence, total score for the 11 questions possible is within the range of 11 to 55 by adding up the individual values based on the response. The total score would indicate participants' knowledge of decision-making, on a range where poor knowledge = 11 and excellent knowledge = 55.

Table 4 indicates the 11 statement items of Section A. Here section A gathers the decision-making knowledge of the participants. The overall participant's response to section A is labeled as Total score Decision Knowledge.

Table 4*The 11 statement items in Section A*

Section A Statement items

1. An important factor that affects the quality of decision-making is the availability of time
 2. It is often the case that decisions made by crew can be reviewed and changed as deemed fit by them
 3. Flight crew should consider making intuitive decisions when faced with time constraints
 4. Decision-making by flight crew are either rule-based or procedure-based only
 5. Seeking accurate and adequate information from appropriate sources is essential for effective decision-making
 6. It is important for crew to identify the root cause of a malfunction for effective decision-making to be able to resolve it
 7. Any malfunction on board could be managed by the procedures and checklists provided by the airplane manufacturer
 8. Having an alternate plan and ascertaining "what if" during decision-making is appropriate
 9. Crew Resource Management is desirable in executing effective decision-making
 10. When faced with a time sensitive problem on flight, a safe outcome can sometimes be achieved by improvising a solution
 11. Do you believe that decision-making training is important in enabling flight crew to make quality decisions on board
-

The first item in Section A sought to investigate whether time available influences decision-making. The purpose of this item was to evaluate how cognizant the crew was of the impact of time on decision-making. The second item "It is often the case that decisions made by crew can be reviewed and changed as deemed fit by them" targeted the aspect of reviewing a decision and changing it as deemed fit. This particular item was posed to investigate participants' inclination to review a decision based upon new evidence or condition presented to effectively consider it and change decision as deemed fit effectively. This could be utilized as an indicator of crew flexibility when faced with changed conditions.

Flight crew often face time constraints and need to make decisions intuitively.

Item 3, “Flight crew should consider making intuitive decisions when faced with time constraints,” asked the crew whether they should consider intuitive decision-making when faced with time criticality. The responses provided indicated the extent to which crew altered decision-making strategy based on time available.

Pilots are highly procedural and rule-based, due to the training provided to them.

Item 4 aimed at eliciting a response to the fact that if they believed that decisions could be solely either rule or procedure based. This question was intended to provide insight into crew opinion on whether they considered decisions at times needed to be neither rule or procedure based, such as in an example of a complex failure involving multiple failures with no clear-cut procedures in place. Item four is as follows: “Decision-making by flight crew are either rule-based or procedure-based only.”

One of the critical aspects of decision-making is to seek and consider accurate and adequate information before formulating a decision. Item number five targeted crew to ascertain to what extent they considered vital for them to consider accurate and adequate information in the decisions they make. A crew who considered this aspect important as compared to a crew who did not could be analyzed to look for impact on decision-making quality. Item five read as follows-“Seeking accurate and adequate information from appropriate sources is essential for effective decision-making.”

Item six was “It is important for the crew to identify the root cause of a malfunction for effective decision-making to be able to resolve it.” It assessed the crew opinion on whether they considered identifying the root cause of malfunction or problem as central to effective decision-making. This item may help in the analysis to ascertain whether a crew is in the know of what exactly is the problem.

Crew resort to procedures and checklists to deal with malfunctions on board. Item seven was designed to test the opinion of the crew on whether the solutions could always be achieved with prescribed procedures and checklists. With a spate of recent complex failures on aircraft like Qantas and others, this insight could be critical in correlating with relevant questions and influence on problem-solving in section B.

Item eight gathered the opinion of the crew concerning an alternate plan and developing “what if” plans well ahead of any developing situation. The item could help in the understanding importance placed by the crew to this particular aspect while involved in decision-making. Item eight read as follows: “Having an alternate plan and ascertaining “what if” during decision-making is appropriate.”

Item nine “Crew Resource Management is desirable in executing effective decision-making” involved understanding to what degree crew placed importance on crew resource management to make effective decisions. Item ten inquired about crew opinion on whether they believed that under time pressure, a safe outcome could be affected by an improvised solution. Item ten read as follows: “When faced with a time-sensitive problem on a flight, a safe outcome can sometimes be achieved by improvising a solution.” Item eleven “Do you believe that decision-making training is important in enabling flight crew to make quality decisions on board” was set out to find out from crew whether decision-making training can be helpful to them.

Section B comprised of 20 questions in all, which aimed to investigate 1) how participants believed they would make decisions in real life situations; and 2) knowledge of decision-making. 9 of the 20 questions were explicitly presented as problem-solving scenarios to measure the decision-making ability of the participants. They are referred to as Decision-Making Ability questions henceforth. The remaining 11 questions in Section B were designed to capture the knowledge on decision-making specifically in the non-normal situations. They are referred to as Decision-Making Knowledge Non-Normal. Each question in Section B is comprised of 3 parts. The first main part of each question tested either the Decision-Making Ability or captured the knowledge on decision-making in the non-normal situations. The second part of each question in Section B labeled as 12a, 13a, and so on, tested the confidence of the participant in answering the main part of the question. The question typically queried the participants as follows:

“In the question directly above, how confident are you that the decision you have made is correct?”

The third part of each question in Section B labeled as 12b, 13b, and so on, tested the confidence of the participant in judging their response to the main question as being safe. The

question typically queried the participants as follows:

“In the question directly above, how confident are you that the outcome of your decision will be safe?”

Both the second and third part of each question were evaluated on a scale with responses ranging from ‘extremely’, ‘very’, ‘moderately’, ‘slightly’, to ‘not at all’. The Likert scale score for both sub-questions were five for ‘extremely’, four for ‘very’, three for ‘moderately’, two for ‘slightly’ and one for ‘not at all’.

The 9 questions in Section B which presented problem solving scenario to measure the Decision-making ability of the participants are the following in Table 5:

Table 5

The 9 problem solving scenario items in Section B

Section B Problem Solving Items

1. You are on a flight from airport A to airport B. At equi-point C, your cabin crew reports visible smoke in the cabin associated with burning smell. Airport D is relatively closer to point C. Airport E is south of airport D. All airports are suitable airports. What is your decision, if you have information that smoke source in cabin is undetermined?
 2. You are on a final approach to landing with the fuel status close to minimum diversion fuel. You get a call from the cabin informing you of 07 guest being disruptive by not being seated and getting physically abusive to the crew. Cabin crew feel unable to control the situation and you persuade them to be seated before the landing is made. What would your decision be?
 3. You are on a diversion due to an engine on fire in flight. You have two adequate alternates available to you, A at 90 nm away and B at 120 nm miles away. The weather at A is light rain with visibility of 3000m (above company minima) with a VOR non-precision approach available and runway surface wet. The weather at B is clear, runway dry and weather with 10 KM and an ILS precision approach. The airport at B in addition has maintenance and passenger support available upon landing. Which airport would you divert to and why?
 4. You are on a flight and find yourself having no extra fuel available at destination. Look at the picture below of weather displayed on navigation display. The green line shows the flight plan route. The wind is from right to left as indicated by redline. Would you continue on the flight plan route (green line) Or deviate to left on blue track or right on yellow track line.? Tick one of the choices below:
 5. Based on aircraft type you fly, assume you have taken off and are climbing on runway heading and passing 2000 ft. At this point you experience an all engine failure. What would be your decision?
 6. You are in cruise in flight. You are navigating around a weather system on your
-

route. Suddenly on your twin engine aircraft, one of the engine flames out (out or on your 4-engine aircraft, two engines flameout). You now begin to carryout the abnormal procedures and the engine relight occurs. You are still few hours away from destination. What would be your decision with respect to continuation of the flight?

10. You are about to take off and lining up on the runway. You see weather on takeoff path about 7 miles ahead. What would be your decision with respect to the takeoff?

15. While cruising at FL280, you happen to encounter some weather and deviate. While deviating, one of the engine flame out occurs (two engines for 4 engine aircraft). As per the aircraft procedures, the drills and checklist are carried out. What would be the crew actions going further with respect to decision-making?

20. You are flying in the vicinity of a weather system and carrying out weather avoidance. Experiencing light turbulence and icing conditions, you decide to deviate further. Suddenly you notice that one of the engines has flamed out. You consider a diversion to nearby airfield. After the procedural flow, you decide to consider restart of the engine. You have a successful restart subsequently. Based on this new condition, would you consider reviewing the decision made on previous information and condition?

Question 1 posed the question to ascertain the participants' decision on the choice of diversion when presented with a problem of smoke in the cabin which is undetermined. This question required a response from the participant on the choice of diversion while ascertaining the gravity of the problem with limited information available. The question was as follows: "You are on a flight from airport A to airport B. At equi-point C, your cabin crew reports visible smoke in the cabin associated with burning smell. Airport D is relatively closer to point C. Airport E is south of airport D. All airports are suitable airports. What is your decision, if you have information that smoke source in the cabin is undetermined?"

Question 2 posed a unique situation requiring decision-making response related to the situation in the cabin with an unruly passenger. Coupling that with a minimum fuel situation, participants were required to mark the most optimal response. This question tested the response of the participants with time pressure since fuel was minimum. The question was

“You are on a final approach to landing with the fuel status close to minimum diversion fuel. You get a call from the cabin informing you of seven guests being disruptive by not being seated and getting physically abusive to the crew. Cabin crew feels unable to control the situation, and you persuade them to be seated before the landing is made. What would your decision be ?”

Question 3 was designed to ascertain participants decision-making in evaluating the choice of airfields available for diversion based on varied conditions, equipment and weather factors. The question was “You are on a diversion due to an engine on fire in flight. You have two adequate alternates available to you, A at 90 nm away and B at 120 nm miles away. The weather at A is light rain with visibility of 3000m (above company minima) with a VOR non-precision approach available and runway surface wet. The weather at B is clear, runway dry and weather with 10 KM and an ILS precision approach. The airport at B, besides, has maintenance and passenger support available upon landing. Which airport would you divert to and why? ”

Question 4 was developed to assess the risk assessment decision-making by participants when evaluating a weather depiction on their radar. The question designed was as follows: “ You are on a flight and find yourself having no extra fuel available at the destination. Look at the picture below of weather displayed on the navigation display. The green line shows the flight plan route. The wind is from right to left as indicated by redline. Would you continue on the flight plan route (green line) or deviate to the left on blue track or right on yellow track line? Tick one of the choices below.”

Question 5 posed a problem which the participants would have to make an intuitive decision with no time available. It could potentially provide participants the flexibility to shift between naturalistic and intuitive decision-making. The question was “Based on aircraft type you fly, assume you have taken off and are climbing on runway heading and passing 2000 ft. At this point, you experience an all engine failure. What would be your decision?”

Question 6 was developed to evaluate the participant's flexibility to change the decision made based on changed conditions. Participants ability to review the decision made, when a change occurs is key to effective decision-making. The question was “ You are in cruise in flight.

You are navigating around a weather system on your route. Suddenly on your twin engine aircraft, one of the engine flames out (or on your 4-engine aircraft, two engines flameout) You now begin to carry-out the abnormal procedures and the engine relight occurs. You are still a few hours away from the destination. What would be your decision concerning the continuation of the flight?”

Question 10 posed a question to participants specifying a take-off condition, to evaluate whether they would review the condition and act upon it. The question was “You are about to take off and lining up on the runway. You see the weather on takeoff path about 7 miles ahead. What would be your decision concerning the take-off?”

Question 15 required participants to make a response considering the context of the failure and acting upon it to take corrective action. The question was “While cruising at FL280, you happen to encounter some weather. You resort to weather deviation as appropriate. While deviating, engine flameout occurs in one of the engines (two engines for 4 engine aircraft). As per the aircraft procedures, the drills and checklist are carried out. What would the crew actions be going further concerning Decision-making?”

Question 20 sought to establish participants ability to prioritize checklist and decisions based on changing condition and review and reconsider decision already made. The question was “You are flying in the vicinity of a weather system and carrying out weather avoidance. Experiencing light turbulence and icing conditions, you decide to deviate further. Suddenly you notice that one of the engines has flamed out. You consider a diversion to a nearby airfield. After the procedural flow, you decide to consider a restart of the engine. You have a successful restart subsequently. Based on this new condition, would you consider reviewing the decision made on previous information and condition?”

Table 6 lists the remaining 11 questions in Section B that were designed to capture knowledge on Decision-making in non-normal situations:

Table 6

The 11 items capturing knowledge on decision-making related to non-normal situations in Section B

Section B Knowledge on Decision-Making in Non-Normal Scenario

7. During an abnormal event, how confident are you that you will be able to identify or get to the root of the problem and fix it?

8. In the event of encountering a complex failure, say an engine failure coupled with landing gear damage and hydraulic fluid loss, on takeoff, how well are you equipped to utilize procedures optimally to address the situation?

9. Do you believe that applying decision-making model helps crew to make better decisions irrespective of sufficient time available or not?

11. In the event of an emergency situation on board with safety impacted, to what extent do you agree with following statement: “Improvising appropriately when faced with unforeseen circumstances leads to achieving the safest outcome”

12. To what extent do you agree to the following Decision-making indicator: “When time available, I would consider as many options available as possible to the problem before zeroing on the best optimal option”.

13. You are in cruise and the cabin crew reports dense smoke coming out of air conditioning vents. Your colleague in the cockpit suggests to verify actual source of fire and smoke and not jump to conclusions that it is an air conditioning smoke. Would you agree to your colleague’s suggestion?

14. During take roll you experience a nose tire burst and confirm that later on climb out on systems page. At the same time, you notice that the left side main gear doors are stuck in open position. Your crew suggests to keep the landing gear down and get a visual pass over control tower to ascertain the extent of damage. Do you believe that by doing so, outcome of Decision-making is enhanced and lead to a safer outcome?

16. With the onset of an acrid smell and smoke in the cabin, crew of an aircraft decide to divert to the nearest airfield ten minutes away. They decide to hold to

Section B Knowledge on Decision-Making in Non-Normal Scenario

complete the checklist systematically before proceeding to land. How well has their decision contributed to maintaining safe operation?

17. You are taxiing for take-off with storm approaching the runway. You decide that you will be able to get airborne before the weather affects the take-off. As you near the take-off point, you decide to rush through the take-off to beat the weather onset. To what extent do you believe that when rushed, the ability to make better decision suffers?

18. You experience a hydraulic failure on departure. You assess that the flight can continue to destination and maintain schedule. Since there is no time pressure to land back, you decide to continue to destination as it is safe and optimal solution. To what extent do you agree to the above decision.

19. When you encounter a problem on flight, how do you currently deal with the Decision-making in solving the problem

For the 9 Section B Decision-Making Ability questions, the score for each question ranged from one to four. The “most correct answer” was allocated a score of four, “moderately correct answer” a score of three, “slightly correct answer” fetching a score of two, and “wrong answer” fetching a score of one. The choices were rank based on safe and efficient answers to the specific scenario by a group of airline training professionals. Each of them involved were asked to provide the most correct response for the question. They were further asked to mark the most correct to the least correct response. Barring few differences, a majority in response ranking was found. Both the sub-questions required participants to denote their confidence in the decision made concerning the problem, and confidence regarding the decision made being safe.

The 11 Section B questions testing Decision-Making Knowledge in Non-Normal situation allocated a score for each of the questions ranging from one to five. The “most correct answer” was allocated a score of five, “almost correct answer” a score of four, “moderately correct answer” a score of three, “slightly correct answer” a score of two, and “wrong answer” fetching a score of one. The choices were ranked by subject matter experts and professionals in the field.

Each of them involved provided the most correct response and the choice ranking were firmed up. Both the sub-questions required participants to denote their confidence in the decision made concerning the problem, and confidence regarding the decision made being safe.

Pilot testing is an integral part of the research process. It is essential to ensure that the measurement instruments in this study are reliable and valid measures of constructs of interest. It was important to ascertain from the targeted audience whether the questions asked were intelligible (Wiggins & Stevens, 1999). Ten participants who were aircrew and familiar with the subject were administered the questionnaire. Based on the feedback received, the questionnaire was appropriately amended for the content, relevance, structure, and grammar. The scoring for each response item was further validated by the aircrew who were flight trainers, subject matter experts and training content developers for pilot training.

Table 7 summarizes the questions in the survey as per the dependent variable scale they represent.

Table 7

Dependant Variables and the survey questions linked to them

Dependent Variable	Survey Questions
1. Section A Decision-making Knowledge	All 11 Questions in Section A
2. Section B Decision-making Ability	Section B Questions - Q1, Q2, Q3, Q4, Q5, Q6, Q10, Q15, Q20
3. Section B Decision-making Knowledge Non - Normal	Section B Questions – Q7, Q8, Q9, Q11, Q12, Q13, Q14, Q16, Q17, Q18, Q19
4. Decision-making Confidence	All Section B Subset Questions
5. Decision-making Safety	All Section B Subset Questions

3.1.5. Procedure

The experimental manipulation was implemented by Group 1 participants having no time limit specified for completion of the survey, while Group 2 had a time limit of 10 minutes for section B. The participants in Group 2 who were administered Set 2 were not only briefed on time limit of 10 minutes, but in the event of being unable to do so, were asked to complete the 20 questions as soon as they can. The time taken was recorded in this case.

The participation was on a voluntary basis. Sampling method adopted was a purposive sampling method. This method was considered because the sample population of airline pilots is small and needed to conform to specific stipulated criteria and experience. (Trochim, 2006). Participants were drawn from 36 various airlines on voluntary basis. An online survey link was sent to participants by various airline representatives. Two of the airlines conducted surveys by providing a hard copy of the survey to the participants during their training events. The survey was administered by training staff who were familiarized earlier on the modalities of how to go about conducting it. The participants were specifically targeted not only by their profession, but also the position and experience held. The survey informed the participant about the research intent and confidentiality. The ethics clearance from Massey University was also mentioned in the survey preamble. Participants were assigned randomly to one of the two arms of the study (time limit vs. no time limit). Participants who were allocated to the time limit condition were advised in the eventuality of not being able to complete in ten minutes, to proceed with the survey expeditiously to complete the survey. The sample questionnaire labeled Set 1 was administered under no time pressure (control condition), and is included in the Appendix A. The sample questionnaire Set 2, administered to flight crew with time pressure of ten minutes in section B (experiment condition) is included in Appendix B.

3.1.5.1. Variables and Measurement

The independent variable for this study was age, experience, position, and time (under pressure vs. not under pressure). The allocation of participants to the two levels of the independent variable ‘time’ was randomized. The measures and variables are described next.

Measurements

Five main dependent variables were assessed. They are:

- 1) Decision-Making Knowledge -Normal (Section A),
- 2) Decision-Making Ability (Section B, 9 questions),
- 3) Decision-Making Knowledge Non - Normal (Section B, 11 questions),
- 4) Decision-Making Confidence (Section B, all subset questions on confidence), and
- 5) Decision-Making Safety (Section B, all subset questions on safety outcome).

The first variable was the total score for Decision-Making Knowledge - Normal, which was taken from 11 questions in Section A to quantify participants' knowledge about aviation decision-making. Each of the 11 questions from Section A defining the variable 'total score Decision-Making Knowledge - Normal had five response choices, where the maximum best score was worth 5 points and the worst response was worth 1 point. Responses to the 'Decision-Making Knowledge' questions were on a Likert scale ranging from 'extremely', 'strongly disagree', 'disagree', 'neither agree nor disagree', 'agree', and 'strongly agree', fetching a score of five for 'strongly agree' to one for 'strongly disagree' in that order. The range of the total score Decision Knowledge - Normal can range from a low total score Decision Knowledge - Normal of 11, to a maximum combined total score of 55. A combined Total score Decision Knowledge - Normal of 11 indicates very poor knowledge of Decision-Making. A combined Total score Decision Knowledge - Normal above 11 and up to 22 corresponding to poor knowledge. A combined Total score Decision Knowledge - Normal above 22 and up to 33 corresponding to average knowledge. A combined total score Decision Knowledge - Normal above 33 and up to 44 indicates good knowledge. A combined total score Decision Knowledge - Normal above 44 and below 55 indicates very good knowledge A combined total score for Decision Knowledge - Normal of 55 corresponds to excellent Knowledge.

The second variable, total score Decision-Making Ability is drawn from the nine scenario-based questions/vignettes in the Section B. The 9 questions from Section B are:

- Question 1 to Question 6, Question 10, Question 15, and Question 20.

Each of these 9 scenario-based or problem-solving questions had four response choices; hence the maximum best score was worth 4 points and the worst response was worth 1 point. The range of the total score Decision-Making Ability possible was from a low total score

Decision-Making Ability of 9 to a maximum combined total score of 36. A combined total score Decision-Making Ability of 9 indicates very poor Decision-Making Ability. A combined total score Decision-Making Ability of above 9 and up to 18 indicates poor Decision-Making Ability. A combined total score Decision-Making Ability of above 10 and up to 27 indicates good Decision-Making Ability. A combined total score Decision-Making Ability of above 27 and below 36 indicates very good Decision-Making Ability. A combined total score Decision-Making Ability of 36 corresponds to excellent Decision-Making Ability.

The third variable, labeled total score Decision-Making Knowledge Non - Normal, is drawn from the eleven questions in Section B which quantify the participant's knowledge of non-normal situations. The 11 questions from Section B are:

- Question 7 to Question 9, Question 11 to Question 14, and Question 16 to Question 19.

Decision-Making Knowledge of Non - Normal situations had five response choices, where the maximum best score was worth 5 points and the worst response was worth 1 point. Responses to the 'non-normal decision-making knowledge' questions were on a Likert scale ranging from 'extremely', 'very', 'moderately', 'slightly', and 'not at all', fetching a score of five for 'extremely' to one for 'not at all' in that order. The range of the total score variable Decision-Making Knowledge Non-Normal, can range from a low total score Decision-Making Knowledge Non-Normal of 11, to a maximum combined total score of 55. A combined Total score Decision-Making Knowledge Non-Normal of 11 was allocated for very poor knowledge of Decision-Making in non-normal situations. A combined Total score Decision-Making Knowledge Non-Normal above 11 and up to 22 corresponded to poor knowledge. A combined Total score Decision-Making Knowledge Non-Normal above 22 and up to 33 was allocated to average knowledge. A combined total score Decision-Making Knowledge of Non-Normal situations above 33 and up to 44 indicated good knowledge. A combined total score Decision-Making Knowledge Non-Normal above 44 and below 55 indicated very good knowledge. A combined total score for Decision-Making Knowledge Non-Normal of 55 was allocated to excellent Knowledge.

The fourth variable was total score Decision Confidence aimed at measuring the confidence in Decision-making ability utilizing the Section B subset question on decision-making confidence. Section B had subset questions investigating the decision-making confidence in all the 20 questions. These questions had the best answer worth 5 points and the worst at 1

point. Responses to the 'confidence' questions were on a Likert scale ranging from 'extremely,' 'very,' 'moderately,' 'slightly,' and 'not at all,' fetching a score of five for 'extremely' to one for 'not at all' in that order. The range of total score Decision Confidence varied from a combined low total score Decision Confidence of 20 to a maximum combined total score of 100. A combined total score Decision Confidence of 20 indicated very poor Decision Confidence. A combined total score Decision Confidence of above 20 and up to 40 indicated poor Decision Confidence. A combined total score above 40 and up to 60 indicates average Decision Confidence. A combined Total score Decision Confidence above 60 and up to 80 corresponded to good Decision Confidence. A combined Total score Decision Confidence above 80 and below 100 was allocated to very good Decision Confidence. A combined Total score Decision Confidence of 100 corresponded to excellent Decision Confidence.

The fifth variable was total score Decision Safety measuring the participant's confidence in the outcome of the decision made is safe. Section B had subset questions investigating the Decision-making safety in all the 20 questions. These questions had the best answer worth 5 points and the worst at 1 point. Responses to the 'safety' questions were on a Likert scale ranging from 'extremely,' 'very,' 'moderately,' 'slightly,' and 'not at all,' fetching a score of five for 'extremely' to one for 'not at all' in that order. The range of total score Decision Safety varied from a combined low total score Decision Safety of 20 to a maximum combined total score of 100. A combined total score Decision Safety of 20 indicated very poor Decision Safety. A combined total score Decision Safety of above 20 and up to 40 indicated poor Decision Safety. A combined total score above 40 and up to 60 indicates average Decision Safety. A combined Total score Decision Safety above 60 and up to 80 corresponded to good Decision Safety. A combined Total score above 80 and below 100 corresponded to very good Decision Safety. A combined Total score Decision Safety of 100 was allocated to excellent Decision Safety.

Participants were scored based on the effectiveness and safety of their decisions, as well as how well the decision follows the federal regulations when compared to a baseline set of answers from an independent flight training expert. It should be noted that the initial questions were vetted through an experienced flight instructor in an open format (non-multiple choice) to examine both questions and answers. The multiple-choice questions were created and

adjusted based on the feedback from training professionals. A couple of questions in Section A which were natively worded were reverse coded accordingly to capture the correct answer. The questionnaires Set 1 and Set 2 are available in Appendix A and Appendix B.

Ethics

Massey University's Human Ethics Committees (MUHEC) has accorded ethics approval for this study. It has been evaluated by peer review and judged to be low risk. Consequently, it has not been reviewed by one of the Massey University's Human Ethics Committees (MUHEC). The researcher named in this document is responsible for the ethical conduct of this research. The MUHEC approval is Attached in Appendix C.

CHAPTER FOUR

Results

The study in addressing the research problem, statistically analyzed the effects of time pressure, knowledge about decision-making, influence on position, experience, and decision-making model on the participants. In this results section, first the descriptive statistics are reported. Next, the results of the effect of time pressure are reported. The effect of position, experience, and the decision-making model are reported. Finally, the decision-making confidence and decision-making safety results are reported.

In total, 358 participants completed the survey. Of these, 48 respondent surveys were in hard copy format, which was migrated to electronic format. Care was taken in data transfer and migration into a single spreadsheet by employing cross-checking data management accuracy. Three independent data integrity checks by three volunteers were accomplished to ensure the data quality and avoid errors due to transfer. All data analyses were carried out using the statistical software package SPSS (version 23.0 for MAC). Depicted in Table 8 are the mean scores of Decision-making Knowledge as measured in Section A under time pressure and no time pressure.

Table 8

Section A Decision-Making Knowledge mean scores

Section A Decision-Making Knowledge Set	Participants <i>n</i>	<i>Mean</i>	<i>Standard Deviation</i>
1 (Control condition)	173	42.89	13.31
2 (Experimental condition)	184	41.06	15.36
Total	357	41.95	14.41

Table 9 displays the mean scores of Decision-Making Ability as measured by the 9 vignettes in Section B under no time pressure and when under time pressure.

Table 9*Section B Decision-Making Ability mean scores (9 vignette questions)*

Section B Decision-Making	Participants		
<i>set</i>	<i>n</i>	<i>Mean</i>	<i>Standard Deviation</i>
1 (Control condition)	173	20.79	8.56
2 (Experimental condition)	184	18.25	10.38
Total	357	19.48	9.61

The results of Decision-Making Knowledge in Non-Normal situations (Section B) are depicted in the Table 10 below:

Table 10*Section B Decision-Making Knowledge of Non-Normal situations mean scores (11 questions)*

Section B Decision-making	Participants		
Knowledge Non-Normal			
<i>set</i>	<i>n</i>	<i>Mean</i>	<i>Standard Deviation</i>
1 (Control condition)	174	22.59	11.58
2 (Experimental condition)	183	18.65	12.97
Total	357	20.57	12.46

Table 11 provides a measure of mean scores of Decision-Making Confidence in Section B

Table 11*Section B Decision-Making Confidence mean scores*

Section B Decision-Making	Participants		
Confidence			
<i>set</i>	<i>n</i>	<i>Mean</i>	<i>Standard Deviation</i>
1 (Control condition)	174	12.78	5.94
2 (Experimental condition)	184	11.72	7.18
Total	358	12.23	6.62

Table 12 measures the participants' perception of safety outcome on decisions made

Table 12

Section B Decision-Making Safety mean scores

Section B Decision-Making Safety set	Participants <i>N</i>	<i>Mean</i>	<i>Standard Deviation</i>
1 (Control condition)	174	12.89	6.05
2 (Experimental condition)	183	11.44	7.02
Total	357	12.14	6.60

Figure 8 displays the spread of survey collected across various airlines. Although the survey was conducted across thirty-six airlines, the bulk of the surveys were from very few airlines. The airlines were de-identified with numbering from 0 to 36.

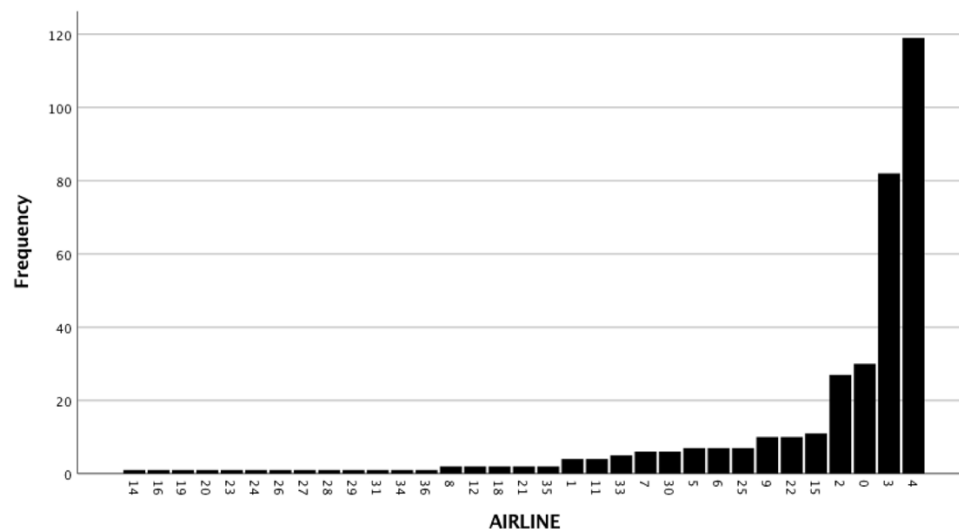


Figure 8 : Spread of survey across 36 airlines.

The Figure 9 indicates the participants aircraft type. Higher samples come from A320 and B737 pilots.

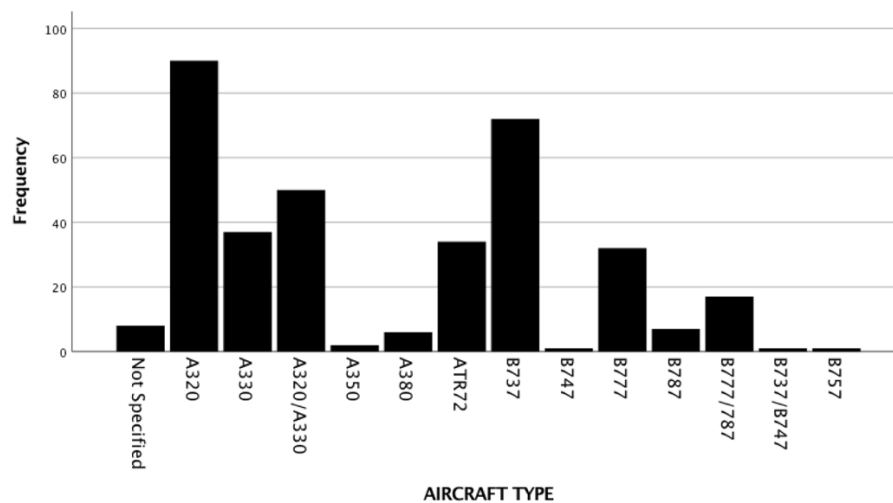


Figure 9: Survey spread with aircraft flown by participants and frequency of survey.

Gender spread amongst 358 participants was 345 male participants, 10 female participants and 3 others who did not specify gender.

176 out of 358 participants were in the greater than 10000 hours category as per Figure 10.

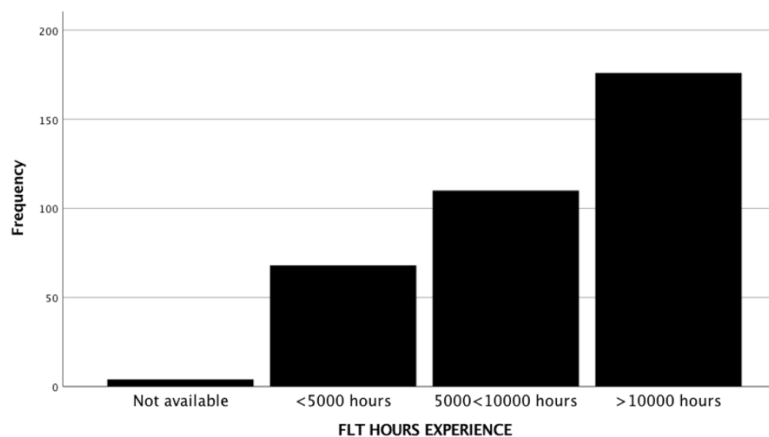


Figure 10 : Survey spread flight hours experience wise.

A reliability analysis (see Table 13) was carried out on participants' responses to Section A; the 11 items yielded a Cronbach Alpha value of 0.954, indicating a very high construct

reliability. Table 14 shows the total statistics for the 11 items, which indicate that the Cronbach's Alpha cannot be meaningfully improved by deleting any single items.

Table 13

Reliability Statistics of Section A

Reliability Statistics		
Cronbach's Alpha	Cronbach's Alpha based on Standardized Items	N of Items
.954	.954	11

Table 14

Total Statistics of Section A question wise

Item-Total Statistics					
	Scale mean if item deleted	Scale Variance if item deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if item deleted
Q1	34.20	140.216	.822	.699	.949
Q2	34.49	142.425	.771	.616	.951
Q3	34.94	145.072	.673	.503	.954
Q4	35.23	146.007	.667	.502	.954
Q5	33.89	137.030	.879	.839	.947
Q6	34.57	141.521	.738	.603	.952
Q7	35.28	147.420	.650	.491	.955
Q8	34.24	138.895	.877	.784	.947
Q9	33.87	137.154	.883	.849	.946
Q10	34.51	140.953	.833	.705	.948
Q11	34.00	137.453	.884	.820	.946

A reliability analysis depicted in Table 15 carried out on section B questionnaire on 9 items indicated a Cronbach Alpha value of 0.921, indicating a high construct reliability. Similarly, Table 16 shows the total statistics for the question items, which indicate that the Cronbach alpha cannot be any further improved by deleting any items.

Table 15

Reliability Statistics of Section B Decision-making Ability questions

Reliability Statistics		
Cronbach's Alpha	Cronbach's Alpha based on Standardized Items	N of Items
.921	.923	9

A reliability analysis carried on section B questionnaire with 9 items indicated a Cronbach Alpha value of 0.921, indicating a high construct reliability.

Table 16

Total Statistics of Section B Decision-Making Ability questions

Item-Total Statistics					
	Scale mean if item deleted	Scale Variance if item deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if item deleted
Q1	19.05	101.450	.778	.666	.908
Q2	20.04	105.588	.575	.416	.921
Q3	19.69	100.792	.726	.580	.911
Q4	19.58	97.958	.761	.613	.909
Q5	20.53	105.463	.580	.364	.920
Q6	20.22	100.924	.761	.638	.909
Q10	20.28	102.271	.783	.635	.909
Q15	20.22	99.883	.788	.715	.907
Q20	19.48	92.481	.759	.657	.911

A reliability analysis depicted in Table 17 carried out on section B questionnaire on 11 items designed to ascertain Decision-Making Knowledge indicated a Cronbach Alpha value of 0.937, indicating a high construct reliability.

Table 17

Reliability Statistics of Section B Decision-Making Knowledge Non-Normal questions

Reliability Statistics		
Cronbach's Alpha	Cronbach's Alpha based on Standardized Items	N of Items
.937	.945	11

Table 18 shows the total statistics for the question items, which indicate that the Cronbach alpha cannot be any further improved by deleting any items.

Table 18

Total Statistics of Section B Decision-Making Knowledge Non-Normal questions

Item-Total Statistics					
	Scale mean if item deleted	Scale Variance if item deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if item deleted
Q7	18.82	133.486	.808	.723	.930
Q8	18.89	133.650	.796	.715	.931
Q9	19.00	134.098	.752	.630	.932
Q11	18.84	132.136	.739	.611	.932
Q12	19.35	138.178	.738	.605	.934
Q13	18.79	129.194	.730	.561	.932
Q14	18.56	125.483	.745	.569	.931
Q16	17.87	116.498	.803	.684	.931
Q17	19.11	132.738	.686	.510	.934
Q18	18.83	129.419	.700	.540	.933
Q19	17.67	114.852	.833	.743	.929

4.1. Analysis of Decision-Making Knowledge - Normal (Section A)

4.1.1. Two-way ANOVA between position and time on Decision-Making Knowledge - Normal (Section A)

A two-way between groups analysis of variance was conducted to explore the impact of participants position and time on the dependent variable Decision-Making Knowledge -Normal (Section A). Participants were divided into Line Captain, Line Co-pilot, Training Captain, and Training Co-Pilot. The interaction effect between participants holding various positions and influence of time was not statistically significant, $F(3, 342) = 2.06, p = .10, \eta p2 = .02$. There was a statistically significant main effect for position, $F(3, 342) = 3.79, p = .1, \eta p2 = .03$. The main for time was not statistically significant, $F(1, 342) = 2.97, p = .09, \eta p2 = .01$. Table 19 depicts the Section A Decision-Making Knowledge for different positions and time influence.

Table 19

Section A Decision-Making Knowledge- Normal for position and time influence

Decision-Making Knowledge Normal	Participants No Time Pressure			Participants Time Pressure		
		Mean	Standard Deviation		Mean	Standard Deviation
	<i>n</i>	<i>M</i>	<i>SD</i>	<i>n</i>	<i>M</i>	<i>SD</i>
1. Line Captain	72	37.76	12.86	85	39.64	10.22
2. Line Co-Pilot	31	39.09	10.96	38	33.34	17.12
3. Training Captain	65	40.64	9.89	52	37.70	14.26
4. Training Co-Pilot	3	29.66	25.81	4	18.25	21.39
Total	171	38.95	11.75	179	37.27	13.79

4.1.2. Two way ANOVA between airline and experience on Decision-Making Knowledge -Normal (Section A)

A two-way between groups analysis of variance was conducted to explore the Decision-Making Knowledge-Normal (Section A) between airline and experience of the crew. The interaction effect between experience and representing airlines was statistically significant,

$F(20, 271) = 1.86$, $p = .02$. There was statistically significant main effect for experience, $F(2,271) = 7.02$, $p < .01$, $\eta p2 = .05$. There was no statistically significant main effect for airline with $F(31, 271) = 1.37$, $p = .09$, $\eta p2 = .14$.

4.2. Analysis on Decision-Making Ability (Section B)

4.2.1. Two-way ANOVA between time and experience on Decision-Making Ability (Section B)

A two-way between groups analysis of variance was conducted to explore the impact of time pressure and experience on the Decision-Making Ability (Section B). The analysis was conducted between three different experience levels, with experience less than 5000 hours, between 5000 and below 10000 hours, and final group above 10000 hours. The interaction effect between participants with various experience levels with time was statistically significant, $F(2, 347) = 3.32$, $p = .04$, $\eta p2 = .02$. There was statistically significant main effect for time pressure, $F(1, 347) = 10.85$, $p < .01$, $\eta p2 = .03$. The main effect for experience was statistically significant with $F(2, 347) = 4.50$, $p = .01$, $\eta p2 = .02$. The Table 20 indicates that mean for Decision-making ability based on experience and time influence.

Table 20

Participants mean and standard deviation on Decision-Making Ability (Section B) score based on flight experience and influence of time

Flight Experience		No Time	Standard		Time	Standard
		Pressure	Deviation		Pressure	Deviation
		Mean			Mean	
hours	<i>n</i>	<i>M</i>	<i>SD</i>	<i>n</i>	<i>M</i>	<i>SD</i>
<5000 hours	33	22.72	8.46	34	14.17	13.09
5000<10000 hours	55	21.90	9.95	55	21.56	10.85
>10000 hours	84	24.32	9.38	92	21.48	10.50
Total	172	23.24	9.41	181	20.13	11.43

4.2.2. Two-way ANOVA between time and position held by crew, on Decision-Making Ability (Section B)

A two-way between groups analysis of variance was conducted to explore the impact of time pressure and position on the Decision-Making Ability (Section B). The section B questions measuring decision-making ability were analyzed. The analysis was conducted between different position held by crew, namely, line co-pilot, Line Captain, Training Captain, and Training Co-Pilot. The interaction effect between position and time was statistically significant, $F(3, 343) = 2.82, p = .04, \eta p2 = .02$. There was no statistically significant main effect for time pressure, $F(1, 343) = 3.44, p = .06, \eta p2 = .01$. The main effect for position was statistically significant with $F(3, 343) = 4.34, p < .01, \eta p2 = .04$. The Table 21 indicates the total mean of position with standard deviation under influence of time.

Table 21

Section B Decision Ability total mean score with position and influence of time

Position		No Time Pressure Mean <i>M</i>	Standard Deviation <i>SD</i>	Time Pressure Mean <i>M</i>	Standard Deviation <i>SD</i>
	<i>n</i>				
Line Capt.	157	19.33	9.63	19.64	9.04
Line Co-pilot	70	21.19	7.15	14.18	12.28
Training Capt.	117	22.88	6.97	19.79	9.92
Training Co-pilot	7	13.33	11.71	11.50	13.77
Total	351	20.79	8.56	18.25	10.38

4.2.3. Two-way ANOVA between time and various participating airlines on Decision-Making Ability (Section B)

A two-way between groups analysis of variance was conducted to explore the impact of time and various participating airlines on the Decision-Making Ability (Section B). The section B questions measuring decision-making ability were analyzed. The interaction effect between time and the airline was not statistically significant, $F(13, 281) = 1.44, p = .04, \eta p2 = .02$.

There was no statistically significant main effect for time pressure, $F(1, 281) = .15$, $p = .70$, $\eta p2 = .00$. The main effect for airline was statistically significant with $F(31, 281) = 1.80$, $p < .01$, $\eta p2 = .17$.

4.2.4. Two way ANOVA between time and whether or not the airline utilized a Decision-Making model in its operations

A two-way between groups analysis of variance was conducted utilizing independent variable time and airline to explore the impact on Decision-Making ability Section B. This analysis is conducted utilizing only two airlines- Airline A which adopted a decision-making model in its operations, and Airline B which does not have a decision-making model. The airline identities are withheld and labeled as airline A and airline B to protect data privacy. The interaction effect between time and the two airlines was not statistically significant, $F(1, 196) = .04$, $p = .83$, $\eta p2 < .01$. There was no statistically significant main effect for airline, $F(1, 196) = 0.61$, $p = .44$, $\eta p2 < .01$. The main effect for time being statistically significant with $F(1, 196) = 9.08$, $p < .01$, $\eta p2 = .04$. Table 22 compares the mean score under time influence between Airline A and Airline B on decision-making ability (Section B). Figure 11 plot depicts the decision-making ability between airline A with decision-making model and airline B with no decision-making model, under the influence of time.

Table 22

Comparison of mean score of Airline A and Airline B on Section B Decision-Making Ability

Airline	<i>n</i>	No Time Pressure		Time Pressure	
		Mean	Standard Deviation	Mean	Standard Deviation
		<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Airline A	82	26.25	7.00	22.00	10.93
Airline B	118	24.94	6.59	21.24	11.10
Total	194	25.20	6.77	21.53	10.98

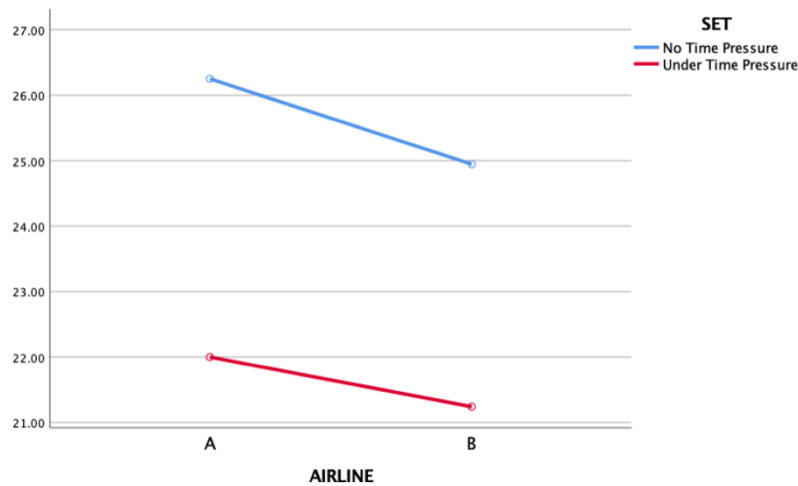


Figure 11. Mean score of Decision-Making Ability between Airline A and Airline B under time influence

4.3. Analysis of Decision-Making Knowledge Non-Normal (Section B)

4.3.1. Two-way ANOVA between time and experience on Decision-Making Knowledge Non-Normal (Section B)

A two-way between groups analysis of variance was conducted to explore the impact of time pressure and experience on the Decision-making Knowledge Non-Normal (Section B). The interaction effect between time and experience levels was statistically significant, $F(2, 347) = 4.31, p = .01, \eta p2 = .02$. There was also statistically significant main effect for time pressure, $F(1, 347) = 14.15, p < .01, \eta p2 = .04$. The main effect for experience was not statistically significant with $F(2, 347) = 2.80, p = .06, \eta p2 = .02$. Table 23 depicts the influence of time and experience on Section B Decision-Making Knowledge on Non-Normal situations.

Table 23

Decision-Making Knowledge on Non-Normal situation (Section B) with time influence and experience

Flight Experience		No Time	Standard		Time	Standard
		Pressure	Deviation		Pressure	Deviation
		Mean			Mean	
<i>hours</i>	<i>n</i>	<i>M</i>	<i>SD</i>	<i>n</i>	<i>M</i>	<i>SD</i>
<5000 hours	34	23.58	11.07	34	12.32	14.27
5000<10000 hours	55	20.12	11.38	55	18.67	11.39
>10000 hours	84	24.83	10.93	91	20.41	11.95
Total	173	22.12	11.12	180	20.13	11.43

4.3.2. Two-way ANOVA between time and position held by crew, on Decision-Making Knowledge of Non-Normal situation (Section B)

A two-way between groups analysis of variance was conducted to explore the impact of time pressure and position on the Decision-Making Knowledge of Non-Normal situations (Section B). The interaction effect between position and time was statistically significant, $F(3, 342) = 2.67, p = .04, \eta p2 = .02$. There was statistically significant main effect for time pressure, $F(1, 342) = 5.93, p = .01, \eta p2 = .02$. The main effect for position was also statistically significant with $F(3, 342) = 3.62, p = .01, \eta p2 = .03$. The Table 24 indicates the mean scores of position and influence of time on Decision-making Knowledge of Non-Normal situations (Section B).

Table 24*Section B Decision Ability total mean score with position and influence of time*

Position		No Pressure Mean	Time Standard Deviation		Time Pressure Mean	Standard Deviation
	<i>n</i>	<i>M</i>	<i>SD</i>	<i>n</i>	<i>M</i>	<i>SD</i>
Line Capt.	72	20.44	11.78	84	19.52	11.74
Line Co-pilot	32	22.93	10.46	38	12.81	13.36
Training Capt.	65	24.15	10.09	52	21.00	11.84
Training Co-pilot	3	17.00	15.13	4	7.50	15.00
Total	172	22.25	11.03	178	18.25	12.50

4.3.3. Two-way ANOVA between time and various participating airlines on Decision-Making Knowledge of Non-Normal situations (Section B)

A two-way between groups analysis of variance was conducted to explore impact of time and participating airlines on the Decision-Making Knowledge of Non-Normal situation (Section B). The interaction effect between time and the airline was not statistically significant, $F(13, 281) = 1.38, p = .16, \eta^2 = .06$. There was no statistically significant main effect for time pressure, $F(1, 281) = .02, p = .86, \eta^2 < .01$. The main effect for airline was statistically significant with $F(31, 281) = 1.50, p = .04, \eta^2 = .15$.

4.4. Analysis of Decision-Making Confidence (Section B)

4.4.1. Two-way ANOVA between time and experience on Decision-Making Confidence (Section B)

A two-way between groups analysis of variance was conducted to explore the impact of time pressure and experience on the Decision-Making Confidence (Section B). The interaction effect between time and experience levels was not statistically significant, $F(2, 348) = 2.56, p = .08, \eta^2 = .01$. There was statistically significant main effect for time pressure, $F(1, 348) = 7.26, p = .01, \eta^2 = .02$. The main effect for experience was also statistically significant with

$F(2, 348) = 3.33, p = .04, \eta p2 = .02$. Table 25 depicts the influence of time and experience on Section B Decision-Making Confidence.

Table 25

Decision-Making Confidence (Section B) with time influence and experience

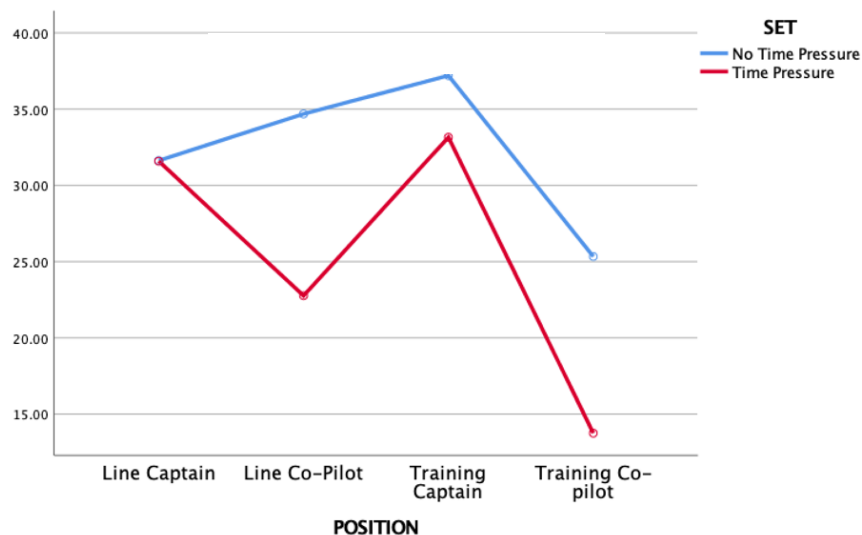
Flight Experience		No Time	Standard		Time	Standard
		Pressure	Deviation		Pressure	Deviation
		Mean			Mean	
<i>hours</i>	<i>n</i>	<i>M</i>	<i>SD</i>	<i>n</i>	<i>M</i>	<i>SD</i>
<5000 hours	34	34.17	15.70	34	21.47	22.35
5000<10000 hours	55	31.45	16.67	55	30.60	17.52
>10000 hours	84	35.58	16.33	92	32.71	18.50
Total	173	33.99	16.33	181	29.96	19.34

4.4.2. Two-way ANOVA between time and position held by crew, on Decision-Making Confidence (Section B)

A two-way between groups analysis of variance was conducted to explore the impact of time pressure and position on the Decision-Making Confidence (Section B). The interaction effect between position and time was not statistically significant, $F(3, 343) = 1.93, p = .12, \eta p2 = .02$. There was no statistically significant main effect for time pressure, $F(3, 343) = 3.50, p = .06, \eta p2 = .01$. The main effect for position was statistically significant with $F(3, 342) = 3.22, p = .02, \eta p2 = .03$. The Table 26 indicates the mean scores of position and influence of time on Decision-Making Confidence (Section B). Figure 12 depicts the plot and the interplay between position and time on decision-making confidence.

Table 26*Decision-Making Confidence(Section B) mean score with position and influence of time*

Position		No Time Pressure Mean	Standard Deviation		Time Pressure Mean	Standard Deviation
	<i>n</i>	<i>M</i>	<i>SD</i>	<i>n</i>	<i>M</i>	<i>SD</i>
Line Capt.	72	31.62	18.11	85	31.58	17.93
Line Co-pilot	32	34.68	14.21	38	22.76	21.59
Training Capt.	65	37.20	14.18	52	33.15	18.40
Training Co-pilot	3	25.33	22.14	4	13.75	21.91
Total	172	34.19	16.17	179	29.77	19.36

*Figure 12: Decision-Making Confidence means with position and time influence*

4.4.3. Two-way ANOVA between time and participating airlines on Decision-Making Confidence (Section B)

A two-way between groups analysis of variance was conducted to explore the impact of time and participating airlines on the Decision-Making Confidence (Section B). The interaction effect between time and the airline was not statistically significant, $F(13, 282) = 1.68, p = .06, \eta^2 = .07$. There was no statistically significant main effect for time pressure, $F(1, 282) < .01, p = .98, \eta^2 < .01$. The main effect for airline was statistically significant with $F(31, 282) = 1.55, p = .03, \eta^2 = .15$.

4.4.4. Pearson Correlation coefficient for Confidence level in decisions made

The relationship between Section B Decision-Making Ability and Confidence level in the decisions made (Section B) was investigated using the Pearson correlation coefficient. There was a strong correlation between two variables, $r = .89$, $n = 358$, $p < .01$, with high levels of confidence associated with section B Decision-Making ability scores. Figure 13 simple scatter plot visually depicts the relationship between Decision-Making Ability and Decision-Making Confidence and indicates the range over which the relationship has been assessed.

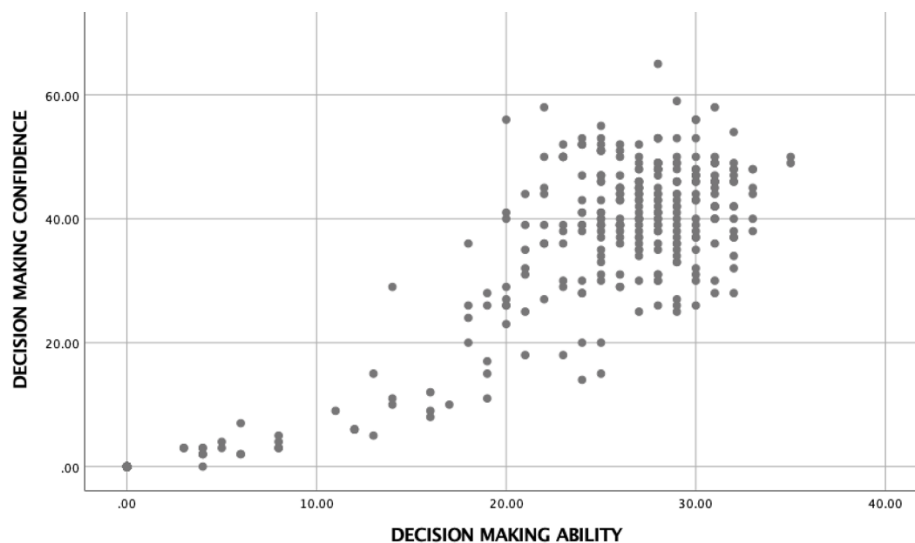


Figure 13: Simple Scatter Plot of correlation between Decision-Making Ability and Decision-Making Confidence of the participants

4.5. Analysis of Decision-Making Safety (Section B)

4.5.1. Two-way ANOVA between time and experience on Decision-Making Safety (Section B)

A two-way between groups analysis of variance was conducted to explore the impact of time pressure and experience on the Decision-Making Safety (Section B). The interaction effect between time and experience levels was statistically significant, $F(2, 346) = 2.85$, $p = .05$, $\eta^2 = .01$. There was statistically significant main effect for time pressure, $F(1, 346) = 8.70$, $p < .01$, $\eta^2 = .02$. The main effect for experience was also statistically significant with $F(2, 346) = 3.99$, $p = .02$, $\eta^2 = .02$. Table 27 depicts the influence of time and experience on Section B Decision-Making Safety.

Table 27*Decision-Making Safety (Section B) with time influence and experience*

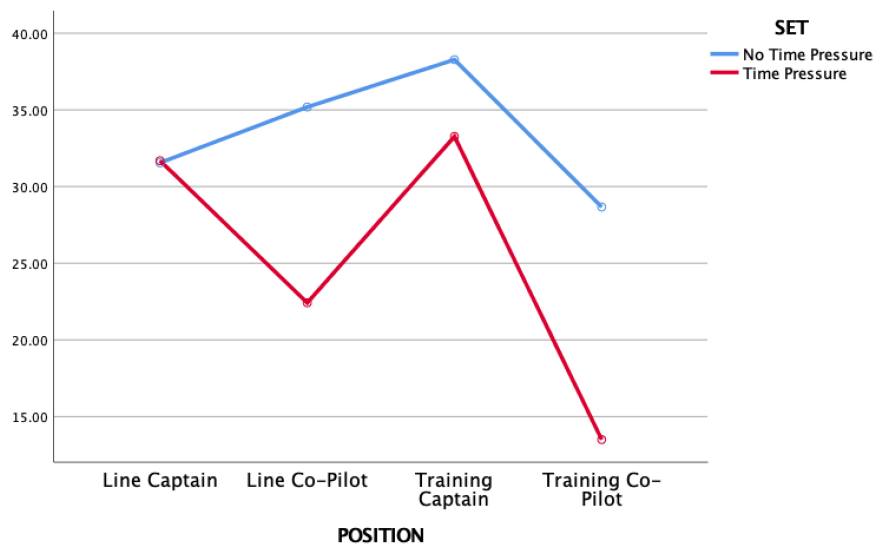
Flight Experience		No Time	Standard		Time	Standard
		Pressure	Deviation		Pressure	Deviation
		Mean			Mean	
<i>hours</i>	<i>n</i>	<i>M</i>	<i>SD</i>	<i>n</i>	<i>M</i>	<i>SD</i>
<5000 hours	34	34.82	16.08	34	21.08	21.91
5000<10000 hours	54	31.35	16.68	55	30.34	17.61
>10000 hours	84	36.46	17.06	91	33.03	18.49
Total	172	34.53	16.81	180	29.95	19.33

4.5.2. Two-way ANOVA between time and position held by crew, on Decision-Making Safety (Section B)

A two-way between groups analysis of variance was conducted to explore the impact of time pressure and position on the Decision-Making Safety (Section B). The interaction effect between position and time was not statistically significant, $F(3, 341) = 2.34, p = .07, \eta p2 = .02$. There was statistically significant main effect for time pressure, $F(1, 341) = 4.85, p = .02, \eta p2 = .01$. The main effect for position was statistically significant with $F(3, 341) = 3.35, p = .02, \eta p2 = .03$. The Table 28 indicates the mean scores of position and influence of time on Decision-Making Safety (Section B). Figure 14 depicts the plot and the interplay between position and time on Decision-Making Safety.

Table 28*Decision-Making Safety(Section B) mean score with position and influence of time*

Position		No Time Pressure Mean <i>M</i>	Standard Deviation <i>SD</i>		Time Pressure Mean <i>M</i>	Standard Deviation <i>SD</i>
	<i>n</i>			<i>n</i>		
Line Capt.	71	31.54	18.56	84	31.69	17.87
Line Co-pilot	32	35.18	14.43	38	22.42	21.14
Training Capt.	65	38.27	14.56	52	33.26	18.65
Training Co-pilot	3	28.66	25.79	4	13.50	21.42
Total	171	34.73	16.65	178	29.76	19.34

*Figure 14: Decision-Making Safety means with position and time influence*

4.5.3. Two-way ANOVA between time and participating airlines on Decision-Making Safety (Section B)

A two-way between groups analysis of variance was conducted to explore the impact of time and participating airlines on the Decision-Making Safety (Section B). The interaction effect between time and the airline was statistically significant, $F(13, 280) = 1.70, p = .05, \eta^2 = .07$. There was no statistically significant main effect for time pressure, $F(1, 280) = .10, p = .75, \eta^2 < .01$. The main effect for airline was statistically significant with $F(31, 280) = 1.50, p = .04, \eta^2 = .14$.

4.5.4. Pearson Correlation coefficient for Decision-Making Safety in decisions made

The relationship between Section B Decision-Making Ability and Decision-Making Safety (Section B) was investigated using the Pearson correlation coefficient. There was a strong correlation between two variables, $r = .88$, $n = 325$, $p < .01$, with high levels of Decision-making safety associated with section B Decision-making ability scores. Figure 15 simple scatter plot visually depicts the relationship between Decision-Making Ability and Decision-Making Safety and indicates the range over which the relationship has been assessed.

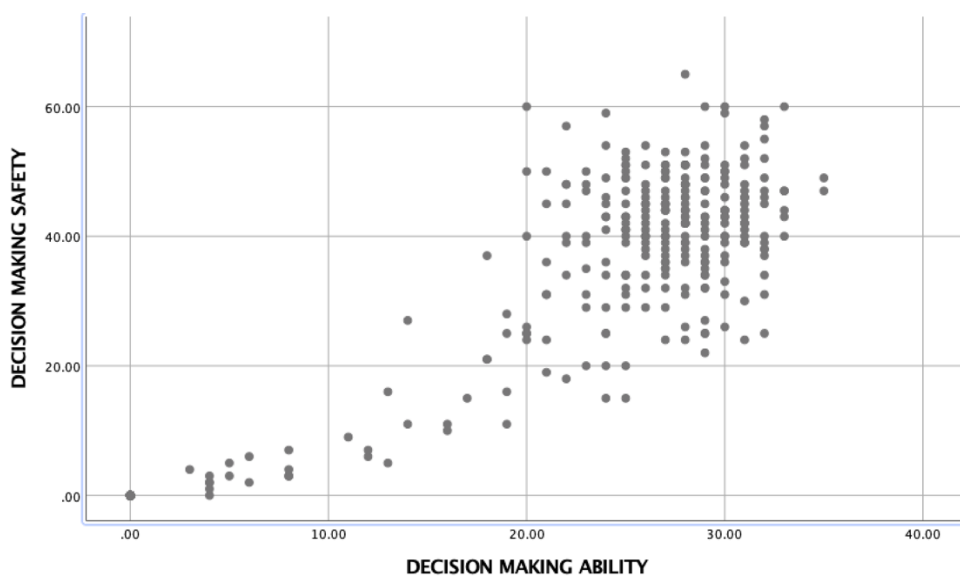


Figure 15: Simple Scatter Plot of correlation between Decision-Making Ability and Decision-Making Safety of the participants

CHAPTER FIVE

Discussion

The primary aim of this study was to investigate the influence of time on decision-making. The data was gathered through a survey by purposive sampling method and analyzed through quantitative methods. The effect of time pressure influenced the decision-making ability and was statistically significant. Evidence was found of statistically significant differences in Decision-making for both position (small effect) and effect of time pressure (medium effect). The interaction effect for co-pilots performance with time pressure was significant, than for a Captains performance. No statistical evidence was found to suggest that adoption of a decision-making model had any benefits over not doing so. There was no evidence of a statistically significant difference between time pressure and post decisional confidence. However, evidence of statistical significant differences was found for post decision safety, i.e., the confidence of the crew about the safety outcome of the decision made. There was no evidence of statistically significant differences in decision-making by experience and effect of time pressure. There was evidence of interaction effect for experience, with low experience (< 5000 hours category) mean score significantly lower than other experience levels when under time pressure.

5.1. Influence of time on Decision-Making of Pilots

Evidence was found of a statistically significant influence of time over decision-making. The mean score for decision-making total score with time pressure was lower than mean score without time pressure. The participants were informed of the 10 minutes time restriction to complete the survey but were allowed to complete the survey.

Time pressure, it had been argued does give rise to stress which affects performance (Paolo & Gioia, 2016). The notion that time pressure induces stress and affects the optimality of the

decision process is well supported by Zakay and Ariely (2001). More often than not, under severe time pressure, it is argued that decision makers underestimate the time available (Kerstolht, 1992). It is widely believed that the underestimation of the available time could be attributable to over-valuing the compensatory effect of increasing their speed of information processing (Maul & Mackie, 1990). Even with information processing speed being constant, the decision-making quality deteriorated under severe time pressure (Kerstolht, 1992). While there are substantial research affirmations (Zakay & Ariely, 2001; Kerstolht, 1992) on the effect of time pressure affecting the decision-making negatively, how can the findings in this study on the effect of time pressure be interpreted?

An investigation into whether time pressure creates the effect of stress on the participants in this study would probably provide some insights. The participants who were subjected to time pressure in this study, were instructed in the survey to continue past 10 minutes restriction placed to answer Section B and the time taken was recorded. The recording of time happened on the hard copy surveys by the coordinator of the survey monitoring and recording the time on the survey details. The online survey had a mechanism of recording elapsed time from the start of section B to the end of it. The average time taken for the time pressure questions in Section B was 18 minutes. While the limit was 10 minutes, it is believed that the participants constantly felt the stress or paucity of time pressure. The stress was created because one had to monitor the passage of time itself while working through the problems. This statement is echoed by Zakay (1993) as discussed in the literature review. Reduced amount of resources are available for decisions under time limits, due to the automatic allocation of attention resources to monitor the time passage. This resource allocation, is what is expected to have occurred when the participants were allowed to complete the survey well beyond the specified time limit of 10 minutes. Another aspect of time is the fact that could it have been better if the participants were stopped after 10 minutes and assessed on the completed vignettes or scenario on decision-making, is a point to be considered perhaps in future study.

Regarding time pressure, if the decisions were to be carried out dynamically under actual flight conditions, could it have been any different, as opposed to a static survey in this study? This aspect could be explored as consideration for future research. That real-time decision

making is inherently stressful is reiterated by Hogarth (1990). In real time, the world will not wait or make time for one to make a decision. It could be a possibility that the participants in being able to continue to work past 10 minutes may not have been potentially constrained from a resources standpoint. Stress is a process necessitated by perceived demands exceeding resources. It would be reasonable to state that stress appears to have manifested in the survey design to elicit time pressure on participants, confirmation of which is indicated by a statistically significant influence of time pressure in the results. Salas et al. (1996) alluded to stress evoking physiological, emotional, cognitive and social changes. How realistically the study evoked the above attributes in the participants to influence decision-making, is the question to ponder over while analyzing these results. Edwards, Lindeman, and Phillips (1965) support this view by stating that dynamic Decision-making can do justice to the complexity of real-world situations. Klein (1993) argued that not enough research exists on dynamic decision-making as compared to static decision-making.

It could be argued that stress in a dynamic environment would result in pushing a participant beyond optimal stress levels and cause undue stress due to the paucity of time. Yerkes and Dodson's (1908) law states that there will be decreased performance when subjected to undue stress beyond optimum. Performance is enhanced when the stress level is low, increasing up to the optimum stress level. The significant decrease in decision-making ability under time pressure could potentially be attributed to stress induced during the experiment in the study. Another view based on the results could be the fact that stress generated by the survey in the study could have been just over the optimal level. The decrease in decision-making ability in the current study could be explained under the framework of Yerkes and Dodson law (1908). It could potentially be that because the stress level experienced is marginally above the optimal level, it resulted in statistical significance and decreased decision-making ability.

It would perhaps be reasonable to examine the vignettes used to test the decision-making of crew itself in inducing cognitive effort by the crew. Aircrew typically in a dynamic situation may exert considerable effort in arriving at problem-solving and decision-making. Two factors that would determine the cognitive load or effort is the ability to define the problem. The more ambiguous a problem is, the more cognitive load or effort is required. Further, the lack of a prescribed response option increases cognitive effort and affects the resulting

decision-making abilities and strategies (Payne et al., 1993). Cognitive effort increases not only due to time pressure but also due to above-mentioned factors which could have impact the study considerably.

Another point of view on influence of time on decision-making could be explained by Schutte (2012) as reviewed in the literature section. Appreciative of the fact that decisions need time, Schutte (2012) alluded that some decisions are made faster and some others with lightning speed. It could well be argued of the possibility that the decision-making vignettes presented to participants may not have been habitual or intuitive non-analytical decisions to them. These habitual or intuitive non-analytical decisions, according to Russo and Shoemaker (1989) may not need extensive information processing. Hence, the vignettes presented to the participants seem to have evoked extensive information processing by not being habitual or intuitive.

5.2. The relationship between experience and Decision-Making of Pilots

The experience category in this study was categorized into less than 5000 hours, 5000 to 10000 hours, and above 10000 hours. The experience category of above 10000 hours and 5000 to 10000 hours seem to make better decision-making than less than 5000 hours category, as suggested by the study. The findings seem to suggest that experience plays a crucial role in decision-making by pilots.

One of the vital components for decision-making quality is experience. Experience is utilized by the decision maker to effectively acquire information, examine and act upon it based on the demands of the task, to arrive at a solution (Wiggins & Bollwerk, 2006). This capacity is enhanced with more task-oriented experiences (Cellier, Eyrolle, & Marine, 1997). Heuristics-based approach validated this study's finding that experienced decision maker is more optimal and timely in encoding information, recall information from memory, integrate, formulate, develop and execute an appropriate response. Experienced decision makers utilize their skills in identifying the cues and defining the problem, thereby reducing the demands on information processing. Compare this to low experience decision makers, who needed to spend more resources on information processing thereby increasing their cognitive load and associated low performance (Wiggins & O'Hare, 2003).

Kennedy et al.'s (2010) study on age and expertise effects on decision found their hypothesis of better decisions with increased expertise was not supported. Kennedy et al. (2010) attributed the hypothesis not being supported due to methodological reasons and specifically to scenarios not producing adequate cues to detect expertise differences. Experts, as studied in Schriver et al. (2008), were adept at noticing cue correlation patterns. Expert pilots, the study added, possessed problem schema or repository that grouped the cues into meaningful patterns (Klein, 1993). What could be the other attributes an experienced pilot exhibits? Schriver et al. (2008) found that pilots with greater amount and type of experience also had greater knowledge and were faster and more accurate in problem diagnosis, even though their cognitive abilities were equivalent to that of the less expert pilots. A contrary finding that less experienced pilots performing better at decision-making than experienced pilots is also noted by Schriver et al. (2008). Less experienced pilots did well on single cue problems due to attention resources. Less experienced pilots looked for single cues and had not attempted an integration of multiple cues as much as the expert pilots did. So effectively the less experienced pilots took action immediately, rather than engage in initiating an extensive search across for cues as an expert pilot would do (Schriver et al., 2008). Another aspect which this study could have addressed is by constructing scenarios which provided little diagnostic cues and verify the decision-making by expert pilots. Schriver et al., (2008) found that expertise benefits were reduced when the experts could not draw on their experience when a lack of diagnostic cues imposes the difficulty. It could be that this study in trying to ascertain decision-making under time pressure, accorded enough cues to the process by way of its scenario design. The abundance of cues, in turn, could potentially have fed the experienced pilots to draw on their experiences and hence result in findings experienced pilots make better decisions.

5.3. Crew Position and Decision-Making

Crew position is also indicative of the experience, and the findings were statistically significant for the position. Line Co-pilot decision-making mean score were significantly low when under time pressure as compared to no time pressure.

Higher experience is associated with a position such as a Captain or Training Captain. In our case, a co-pilot with comparatively lower experience exhibited significant lower decision

making score under the influence of time pressure. Experienced pilots automate their processes required for decision-making and ultimately chunk them to reduce the cognitive load (Bielock, Wieranga, & Carr, 2002).

While the findings in this study concerning line co-pilot and low experience are highly correlated, there is contradictory evidence to that effect. Experience as a pilot in command, rather than total experience or recent experience, was hypothesized to better performance in decision-making. Another study found that for the development of cognitive skills, active participation as a pilot in command made an impact more than mere involvement in a task. (Barsam & Simutis, 1984; Kashihara, Kinshuk, Oppermann, Rashev, & Simm, 2000).

5.4. Influence of Decision-making Model

A two-way between-groups analysis of variance between two airlines, one with decision-making model and the other without a decision-making model was conducted. The interaction effect between participants holding various positions and from the two airlines was found to be statistically not significant. The airline without a decision-making model in practice was not at a disadvantage when compared with an airline with a decision-making model.

Decision-making models came into existence when it was recognized that decision-making is critical to the safety of operating an aircraft (FAA, 2014). When aircrew are faced with an unexpected event in flight, rational decision-making is the ideal choice. The fact or possibility that the aircrew may not have previously experienced the problem presented in flight is a possibility. While most of the abnormalities may have been practiced or experienced before, there is every possibility of encountering a failure which is a new experience. While aircrew experience could be handy in dealing with varied abnormal situations, large elements could still be effectively new and unpractised by a crew. Hence, faced with a situation where a diagnosis is not a given, aircrew may have to deliberate it and decide on a course of action. The abnormality may not be clear, and this is where an acronym or decision-making model is said to assist (CAP737, 2014). What could be the potential merit of using or organizing a decision-making process with a model? FAA (2014) recognized decision-making as critical to safe operation of aircraft and recommended using a decision-making model. Studies by Li (2006) and Harris (2008) found improvement in pilot situational assessment and risk management

using the decision-making model.

If the merits of the decision-making model discussed previously were to be materialized, the findings of this study should have probably indicated a statistically significant influence for the airline crew practicing the decision-making model as a policy. The total mean scores for an airline with the decision-making model adopted is marginally higher than for airline without decision-making process. Based on the current study findings, could it be possible that aircrew trained in decision-making model is no better than aircrew not adopting a decision-making model?

The study by Jarvis (2007) did not find any strong evidence that was using decision aids such as decision-making models, FORDEC or DECIDE, made a positive impact upon general aviation pilots on decision outcomes. Use of the decision-making model is valid when time and information are clear. Time pressure, it is argued makes it unsuitable to situations. It might be worthwhile sometimes under time pressure to resort to shortcut tactics or intuitive decision. Time is the decider as to the strategy to deploy the classic decision-making model or intuitive decision (Young et al., 2012).

In trying to understand the results of this study, it would be appropriate to reflect upon the results and specifically the total mean score for both airlines with and without time pressure. Notice the mean score for airline with decision-making model under no time pressure, which utilizes decision-making aid, and decision-making model are higher than for airline which does not utilize a decision-making model. Under no time pressure, the airline with decision-making model, utilized decision-making aid far better than airline with no decision-making model, as the use of a decision-making model it appeared was effective when the time is not critical. The study by Young et al., (2012) found that time is the decider in the use of strategy whether to use a decision-making model or not. Results of the study also depicts the airline with decision-making model had total mean score with time pressure drop extensively. Compare this to the airline with no decision-making model, which had a comparatively shallower drop in total mean score under time pressure. As hypothesized from previous studies (Jarvis, 2007; Young et al., 2012), under time pressure, the decision-making score mean for airline 3 utilizing decision-making aid/model drops to a greater extent. In other words, the use of decision-

making aid under time pressure is not optimal. Hence, the inference that could be deduced and argued is that under time pressure, the decision-making model utilization is not optimal, as per the findings in this study.

What then could be the advantage of familiarizing the crew on a decision-making model and adopt an acronym for the aircrew to utilize it? FAA (1991a) defined aeronautical decision-making as follows:

“ADM is 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 ” (FAA ADM, 1991a, p.2-2).

In aviation, decision-making is critical as it has safety implications. Decision-making in aviation is carried out in a dynamic and complex environment (Zsombok & Klein, 1997). Aircrew may not be able to perceive, evaluate, understand and act on all aspects of the environment. The decision maker must simplify and make a decision, within, as Reason (1990) calls it “bounded rationality.” Aircrew in an airline environment consists of two or more members. With time available, the decision-making model drives them to use knowledge-based reasoning and run a mental simulation and then integrate, assign meaning and project the future behavior or state and act upon it (Elgin & Thomas, 2004). Decision-making model is a simple process to enable aircrew to systematically work towards a solution, when time is not a factor, to choose a course of action from a plethora of choices available (Skybrary, 2010). Aircrew under time pressure needs to adapt and change course to address the situation. Prescriptive procedures are difficult to apply under time pressure and in a complex environment (Klein & Orasanu, 1993). Decision-making in aviation must be a continuum of processes in order to adapt effectively to constraints and changes occurring regularly. It could continuously change from being a decision-making model to intuitive decision-making (FAA, 2010). It may be then argued that the findings in the current study indicated that adopting a decision-making model is not good enough. It is the ability to adapt to changes and process information, keeping in mind time factor that will enable aircrew to tackle situations and address them safely and effectively. The limitation here, of course, is the fact that the study has not captured the information as to how the cognitive processes were being prioritized or managed by participants. Also the fact that the crew of the airline without a decision-making model may

have been familiarised with the decision-making process formally or informally, setting a bias into the findings itself. Also, the generalizability of the findings may be affected due to the fact that the study was static. Dynamically observing and evaluating aircrew work in high fidelity simulated situations could help the findings to be generalized to a wider population.

5.5. Post-Decisional Confidence and Post-Decisional Safety

Post-decisional confidence was measured after a scenario, or a vignette was presented within the question as a subset question. The post-decisional confidence measure is to gauge the confidence in the decision made in the preceding problem-solving scenario. The measurement utilizing the Pearson correlation coefficient between decision-making score (Section B) and Confidence level score was investigated with a strong correlation, indicating high confidence in decisions made.

The results of this study on decision-making confidence and interaction with participants with the influence of time were not statistically significant for the influence of time. While the time constraint reduced the mean scores for all participants, the notable deterioration was concerning least experience category, i.e., the participants with less than 5000 hours.

Smith, Mitchell, and Beach (1982) investigated the effects of time constraint and found subjects preferred structured decision-making model and that confidence in the decision-making decreased with time pressure. Findings of this study confirmed that confidence is not decreased under time pressure. The preference of decision-making strategy of the participant cannot be verified from the findings of this study. Zakay (1985, as cited in Svenson & Maule, 1993) asserted by stating that one would expect participants to be comfortable with compensatory strategies.

Zakay (1985) investigated the relationship between time pressure, type of decision process, and post-decisional confidence. Subjects later rated their post-decisional confidence. Zakay (1985) found that under time pressure, there was a more frequent use of non-compensatory decisions and the post-decisional confidence was greater as compared to decisions with compensatory strategies. More frequent use of non-compensatory strategies was unexpected in light of the assertion that participants prefer compensatory strategies. Relating to the finding in this study, the post-decisional confidence not being significant under time pressure could potentially be deduced that probably the use of non-compensatory strategies being resorted to

as frequently as required. The findings of this study are contrary to the assertion by Zakay (1985) that participants prefer compensatory strategies. Are the findings in this study potentially influenced by the airline training and adoption of the decision-making model that participants do not resort to non-compensatory strategies when required?

Further investigation was carried out between two airlines, one that has adopted a decision-making model and one that has not. On comparison of decision confidence, the confidence decreased for both airlines under time pressure, and the overall confidence for the airline with the decision-making model remained high. Could this potentially guide us to investigate the possibility that an airline is adopting a decision-making model and training increase the overall confidence in decisions made by participants? That could be an opportunity for further study to evaluate this aspect.

Post-decisional safety outcome was measured in a subset question after a scenario, or a vignette was presented. The post-decisional safety measure was to gauge the participant's confidence in the decision made from a safety perspective in the problem-solving scenario. The measurement utilizing the Pearson correlation coefficient between decision-making Ability score (Section B) and Confidence Safety score was investigated with a strong correlation between both variables, indicating high confidence in safety in decisions made.

The results of this study with two-way ANOVA with time and experience to ascertain the confidence of participants in the safety of their decision (having made a decision) was conducted. There was evidence of statistically significant interaction effect between participants' experience, and the effect of time influence. Further, there was evidence of a statistically significant influence of time (main effect). The low experience group of a category with experience under 5000 hours had significantly lower confidence in safety compared to other experienced groups. Under time pressure, the low experience group as with the other groups had lower confidence in safety indicated. These findings again could be viewed in the framework of the utilization of non-compensatory strategies, be it experienced or low experience participants. Greater confidence in safety again seems to occur when not influenced by time pressure, which then does not require the non-compensatory strategy (Zakay, 1985) to be utilized. On scrutiny of the relative confidence in the safety of the decisions made, statistical evidence was found for increased confidence in safety associated with increased

experience levels. Could this be that with increased knowledge, task familiarization and exposure that the confidence in safety occurs? What about crew preference for risky choice under time pressure? Participants make less risky choices under severe time pressure (Ben Zur & Breznitz, 1981). Does this manifest an increase in confidence in safety? Are their perception and confidence in safety representative of actual conditions? An opportunity exists for potential dynamic research in high fidelity simulated conditions wherein we could interview the participants alongside the experiment to find the critical attributes that influence perception of safety while making decisions.

Limitations of the Study

In this experimental investigation of decision-making by pilots under time pressure, a set of research hypothesis were formulated. The study captured 358 samples, and it was spread over 36 airlines around the world. However, the majority of the data (259) came from 6 airlines. It was felt that in researching the hypothesis of whether adopting a decision-making model helps airline pilots to make better decisions, the survey might have been broad-based. As a result, researching this hypothesis was confined to two airlines which provided the majority of the data and where confirmation was possible on whether the airline adopted a decision-making model or not. Another aspect was that the survey was initially conducted at airline locations with hard copy questionnaire, which was later propagated along with electronic survey.

It was felt that although participants were informed of the survey on a voluntary basis, coming at the end of a ground training session, they may have felt the need to do the survey and comply, considering the cultural aspects at some of the locations where the survey was done. Another limitation is that although the scenarios designed were realistic and crew are trained to handle such emergencies, merely by being a paper decision-making exercise, the inclination of the crew to make an exactly similar decision as noted in the survey could be debatable. Operating in an actual environment or simulated environment, could bring in additional changes from a paper survey such as this, and may influence the way decisions are made. Another aspect that was not ascertained from participants was whether they were formally trained in the decision-making process, which could have helped to compare data on those were trained and those who were not.

Design of the questionnaire could be influenced by serial order effect. Serial order effect is observed when responses to items included later in a questionnaire are influenced by items that appear in an earlier section. This serial order effect, according to Steinberg (1994) is due to respondents narrowing their attention towards the particular construct under investigation, rather than interpreting each question independently. However, this effect may also be due to fatigue, mainly when the questionnaire comprises a large number of items. This could have been potentially affected this study as the questionnaire had large number of items. The primary outcome of the serial-order effect is a difference between the items answered during the earlier stage of a series of trials, and those answered during later stages (Wiggins & Steven, 1999). That said, as all participants completed all items in the same order, this is unlikely to have confounded the findings overall.

A final potential limitation was that the order of the two types of items in Section B was not as well randomized as it could have been. This was an oversight in the design phase of the survey. However, as all participants completed items in the exact same order, it is considered unlikely this will have seriously affected the final analyses.

Ideas for further research

Further research in decision-making to replicate the current study could be undertaken to investigate the effect of time influence by studying scenario-based training in a flight simulator. Since the scenario-based training or line-oriented flight training in a simulator provides realism and dynamic flight situations, it could help in more reliable and valid findings. Another idea for further research could be to involve flight and cabin crew with a well thought out table top exercise in decision-making. The crew may be led through a scenario with flash information cards and problems presented through them. Monitoring and observing the crew behaviour and decision-making, could help further replicate this study on time effects of decision-making.

Recommendations

While this study accomplished the goals it set, a lot of questions have surfaced that will need to be potentially addressed in future studies. First, while the sample size was large enough, most of the participants were spread over 36 airlines, making the samples from most of the airlines small or limited. In order to address generalizability of the findings to a greater airline

pilot population in studying the time influence in decision-making, increasing the overall sample size, and specifically sample size for each airline could be helpful.

The proposed study could also consider using the survey instrument utilizing the repeated measures methodology. The repeated measures design being able to utilize fewer participants to detect a desired effect size. Another advantage is that the repeated measures design can track an effect over time by measuring the same participant at various times. By obtaining multiple measurements over time, the drawback also is the introduction of the order effect. The overall scores may decrease over time due to fatigue or may increase decision-making of participants. Order effect may be overcome by counterbalancing the test administration.

Another research problem that needs to be revisited is the influence of time pressure on pilots with low experience. It would augur well if research were to be explicitly targeted to ascertain the management of cognitive load by participants. While the findings in this study point toward better cognitive load by experienced pilots than by low experienced pilots, a specifically targeted questionnaire survey could help clarify that finding further. It is argued that less experienced pilots perform well on managing cognitive load when subjected to a single cue. Expert pilots benefitted when the situation presented them with sufficient diagnostic cues to draw on their experience and make better decisions problems (Schrivier et al., 2008). A further study targeting low experienced pilot group to single cues, and presenting lesser diagnostic cues to more experienced pilots, could help study the effect of cues on cognitive load and decision-making.

Research design in a full flight simulator with the scenario presented to the crew to handle dynamically could potentially exhibit findings with probably an accurate measure of stress effect. As compared to a survey, in a dynamic simulator scenario, the crew may experience undue stress, and coupled with the time factor, result in high cognitive load. In a dynamic situation, there being no possibility of extending time to solve a problem as was done in the current study, could result in more realistic findings.

CHAPTER SIX

Conclusion

The present study aimed to test whether time factor influenced decision-making by airline pilots. Further, the effect of experience, the position held, decision-making knowledge in normal and non-normal situations, decision-making confidence and confidence in safety were evaluated. Airline utilizing prescriptive decision-making model and airline not utilizing the decision-making model were compared for decision-making.

Evidence was found of statistically significant effect of time on decision-making. Additional findings from the present study suggested that there was no difference in the decision-making ability of pilots from the airline with a decision-making model and without a decision-making model. However, the line co-pilots in this study exhibited significant lowering of decision-making ability in the experimental condition, i.e., under time pressure as compared to a control condition with no time pressure. There were no statistically significant findings for post-decision confidence. The study revealed a statistically significant influence on post-decision safety. Interaction effect for experience was noted with low experience exhibiting lower confidence in safety as opposed to participants with higher experience.

Schutte (2012) found that some decisions are made faster and some at lightning speed. It is further elaborated by Russo and Shoemaker (1989) who indicate that some decisions may not need extensive information processing. It could be well argued that the challenges presented to participants may not have been habitual or intuitive non-analytical decisions, requiring extensive information processing. Hence, a statistically significant influence of time was noted on line co-pilots.

This study was able to confirm the finding by Jarvis (2007) that using decision-making models did not have any positive impact on decision outcomes by airline pilots. The plausible explanation being that time decides the strategy to adopt intuitive or classic decision-making (Young et al., 2012).

It is worthwhile to note that this present study was able to conclude decisively that time factor influences the decision-making. Of interest is the fact that the present findings in this study were done through purposive survey methodology. These results arising out of the survey may not be the same in a real-time situation or dynamic situations. An instrument capable of reliably detecting the stress and time influence on decision-making could potentially be utilized to validate the findings in this study. Use of flight simulator for the study could help capture the effects of stress and time on decision-making in a dynamic environment (Edwards, Lindeman, & Phillips, 1965).

It is concluded that the effect of the time pressure on decision-making was significant in the current study. Adoption of prescriptive decision-making model seemed to have no advantage in the decision-making ability of airline pilots. Post-decisional confidence was not statistically significant under time pressure. Post-decision safety perception seemed to decline under time pressure and was statistically significant. Higher experience levels showed relatively higher confidence in post-decisional safety.

Lastly, the findings from the present study suggest that the line co-pilots with their low experience seemed to suffer significantly on decision-making ability when under time pressure. This finding is considered to be significant as the main thrust of this study related to the influence of time pressure on decision-making.

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APPENDICES

Appendix A. Decision-Making Survey Questionnaire

DECISION MAKING SURVEY
DECISION MAKING SURVEY

ABOUT MYSELF:

I'm an airline pilot pursuing Master studies in Aviation and conducting research thesis on decision making survey with Massey University in New Zealand. The subject that I chose to research is the decision making by pilot's and their influence under time. This survey is voluntary and your participation is anonymous. Your name will not be collected nor will your identity linked to results. The survey may take between 15-20 minutes. Thank you for volunteering. This may help us better understand the decision making amongst various pilots and organizations better. -- Srinivas Rao

ETHICS CLEARANCE

This has been evaluated by peer review and judged to be low risk. Consequently, it has not been reviewed by one of the Massey University's Human Ethics Committees. I will be responsible for the ethical conduct of this research. If you need additional information about this survey, you may email me at srao330@gmail.com. If you have any concerns about the conduct of this research that you want to raise with someone other than the me, please contact [Dr. Brian Finch](#), Director (Research Ethics), email : humanethics@massey.ac.nz.

BACKGROUND FOR THIS RESEARCH

Aviation accident reports point to tactical decision making errors by pilots exacerbated by paucity of time available. Decision making skills of pilots may be influenced by time available to them. Experience and training in decision making may influence how pilots respond when faced with an abnormal event under time constraints. Research points to paucity of time restricting the amount of analysis and the cognitive processing the human mind can do.

PURPOSE OF THIS RESEARCH

The purpose of this research is to study the decision making ability of pilots, and the effect time has on it. The research also aims to study the influence experience and training may have on the quality of decisions made by pilots. Your participation would help further understanding of decision making and make an impact on safety in aviation.

If you are a commercial pilot (airline, general aviation or charters), willing to volunteer to participate in the survey, and understand the terms detailed in this page, you may click to proceed with the survey.

Click NEXT below to Start the Survey

DECISION MAKING SURVEY

DEMOGRAPHIC INFORMATION

This section requires you to fill in your details.

1. Which airline do you work for ?

2. Gender (Please tick one) :

- ☐ MALE
☐ FEMALE

3. AGE (Please tick one) :

- ☐ < 25 years
☐ 25-35 years
☐ > 35 years- 45 years
☐ > 45 years

4. What is your flight experience (please tick one)?

- ☐ < 5000 hours
☐ 5000 < 10000 hours
☐ >10000 hours

5. What is your current position (please tick one)?

- ☐ Line Captain
☐ Line Co-Pilot
☐ Training Captain
☐ Training Co-Pilot

6. What aircraft type of you fly?

☐ A320

☐ A330

☐ A320/A330

☐ A350

☐ A380

☐ ATR 72

☐ B737

☐ B747

☐ B777

☐ B787

☐ B777/B787

☐ Other (please specify)

DECISION MAKING SURVEY

SECTION A -- OPINION ON DECISION MAKING-- NO TIME LIMIT TO COMPLETE THIS SECTION

This section contains 11 statements describing some aspects of decision making that you might face as a pilot. Please tick the most appropriate response. There are no right or wrong answers and we are simply interested in how you personally respond. There is no time limit to complete this section.

1. An important factor that affects the quality of decision making is the availability of time

- ☐ Strongly disagree
☐ Disagree
☐ Neither agree nor disagree
☐ Agree
☐ Strongly agree

2. It is often the case that decisions made by crew can be reviewed and changed as deemed fit by them

- ☐ Strongly disagree
☐ Disagree
☐ Neither agree nor disagree
☐ Agree
☐ Strongly agree

3. Flight crew should consider making intuitive decisions when faced with time constraints

- ☐ Strongly disagree
☐ Disagree
☐ Neither agree nor disagree
☐ Agree
☐ Strongly agree

4. Decision making by flight crew are either rule-based or procedure-based only

- ☐ Strongly disagree
- ☐ Disagree
- ☐ Neither agree nor disagree
- ☐ Agree
- ☐ Strongly agree

5. Seeking accurate and adequate information from appropriate sources is essential for effective decision making

- ☐ Strongly disagree
- ☐ Disagree
- ☐ Neither agree nor disagree
- ☐ Agree
- ☐ Strongly agree

6. It is important for crew to identify the root cause of a malfunction for effective decision making to be able to resolve it

- ☐ Strongly disagree
- ☐ Disagree
- ☐ Neither agree nor disagree
- ☐ Agree
- ☐ Strongly agree

7. Any malfunction on board could be managed by the procedures and checklists provided by the airplane manufacturer

- ☐ Strongly disagree
- ☐ Disagree
- ☐ Neither agree nor disagree
- ☐ Agree
- ☐ Strongly agree

8. Having an alternate plan and ascertaining "what if" during decision making is appropriate

- ☐ Strongly disagree
- ☐ Disagree
- ☐ Neither agree nor disagree
- ☐ Agree
- ☐ Strongly agree

9. Crew Resource Management is desirable in executing effective decision making

- ☐ Strongly disagree
- ☐ Disagree
- ☐ Neither agree nor disagree
- ☐ Agree
- ☐ Strongly agree

10. When faced with a time sensitive problem on flight, a safe outcome can sometimes be achieved by improvising a solution

- ☐ Strongly disagree
- ☐ Disagree
- ☐ Neither agree nor disagree
- ☐ Agree
- ☐ Strongly agree

11. Do you believe that decision making training is important in enabling flight crew to make quality decisions on board

- ☐ Strongly disagree
- ☐ Disagree
- ☐ Neither agree nor disagree
- ☐ Agree
- ☐ Strongly agree

DECISION MAKING SURVEY

This section is time limited section. Kindly fill in the start time below.

You are expected to endeavour to finish in approximately 10 minutes. If unable to, continue to complete the 20 questions and record the completion time.

* ENTER THE START TIME example 1044

Time

 -

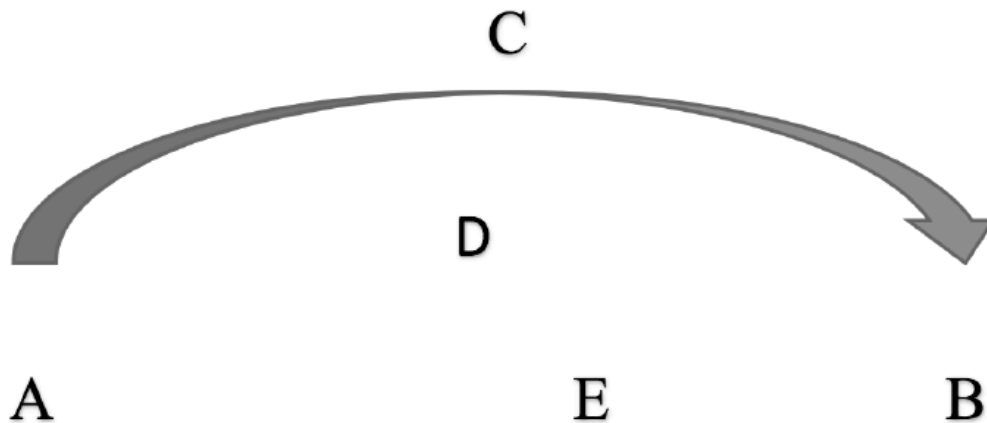
DECISION MAKING SURVEY

SECTION B--DECISION MAKING- TIME LIMIT 10 MINS FOR THIS SECTION

For each of the following 20 vignettes, imagine that you are the pilot in charge. Please mark the most correct response for each of the question using a tick. You have a time limit of 10 minutes to complete the following questions. However, if unable to complete, continue to answer all 20 questions and record the time taken to finish.

1. You are on a flight from airport A to airport B. At equi-point C, your cabin crew reports visible smoke in the cabin associated with burning smell. Airport D is relatively closer to point C. Airport E is south of airport D. All airports are suitable airports. What is your decision, if you have information that smoke source in cabin is undetermined?

A. Proceed to B B. Turn back to A C. Proceed to point D D. Proceed to point E



Choose the best answer

- ☐ Proceed to B
- ☐ Turn back to A
- ☐ Proceed to point D
- ☐ Proceed to point E

1a. In the question directly above, how confident are you that the decisions you have made is correct?

- ☐ Extremely
- ☐ Very
- ☐ Moderately
- ☐ Slightly
- ☐ Not at all

1b. In the question directly above, how confident are you that the outcome of your decision will be safe?

- ☐ Extremely
- ☐ Very
- ☐ Moderately
- ☐ Slightly
- ☐ Not at all

DECISION MAKING SURVEY

SECTION B--- DECISION MAKING WITH TIME LIMIT 10 MINUTES

2. You are on a final approach to landing with the fuel status close to minimum diversion fuel. You get a call from the cabin informing you of 07 guest being disruptive by not being seated and getting physically abusive to the crew. Cabin crew feel unable to control the situation and you persuade them to be seated before the landing is made. What would your decision be?

- ☐ I will go around as landing without passengers being secured is a safety threat
- ☐ I will not go around considering fuel status is close to minimum diversion fuel
- ☐ I will not go around as disruptive passengers can be better dealt on ground in timely manner.
- ☐ I will go-around as disruptive passengers in cabin is serious and need to be sorted out before attempting a landing.

2a. In the question directly above, how confident are you that the decision you have made is correct?

- ☐ Extremely
- ☐ Very
- ☐ Moderately
- ☐ Slightly
- ☐ Not at all

2b. In the question directly above, how confident are you that the outcome of your decision will be safe?

- ☐ Extremely
- ☐ Very
- ☐ Moderately
- ☐ Slightly
- ☐ Not at all

DECISION MAKING SURVEY

SECTION B--- DECISION MAKING WITH TIME LIMIT 10 MINUTES

3. You are on a diversion due to an engine on fire in flight. You have two adequate alternates available to you, A at 90 nm away and B at 120 nm miles away. The weather at A is light rain with visibility of 3000m (above company minima) with a VOR non-precision approach available and runway surface wet. The weather at B is clear, runway dry and weather with 10 KM and an ILS precision approach. The airport at B in addition has maintenance and passenger support available upon landing. Which airport would you divert to and why?

- ☐ Airport A as it is the closest and the weather minima is above company minima
- ☐ Airport B as the weather is clear and runway surface is dry and ILS approach available
- ☐ Airport A as it is the closest and since the engine is still on fire, time is of essence.
- ☐ Airport A as it is the closest and since the engine is still on fire, time is of essence.

3a. In the question directly above, how confident are you that the decision you have made is correct?

- ☐ Extremely
- ☐ Very
- ☐ Moderately
- ☐ Slightly
- ☐ Not at all

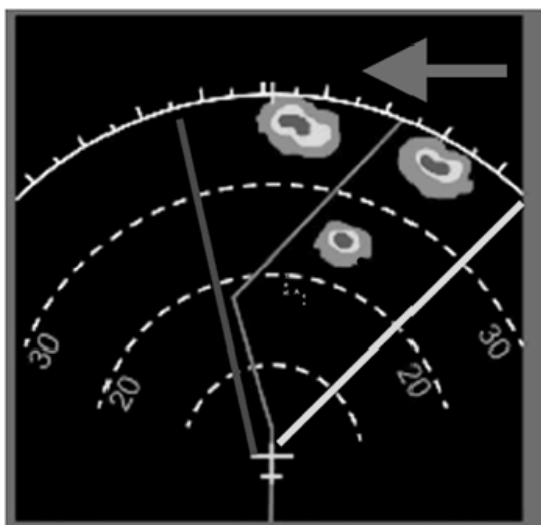
3b. In the question directly above, how confident are you that the outcome of your decision will be safe?

- ☐ Extremely
- ☐ Very
- ☐ Moderately
- ☐ Slightly
- ☐ Not at all

DECISION MAKING SURVEY

SECTION B--- DECISION MAKING WITH TIME LIMIT 10 MINUTES

4. You are on a flight and find yourself having no extra fuel available at destination. Look at the picture below of weather displayed on navigation display. The green line shows the flight plan route. The wind is from right to left as indicated by redline. Would you continue on the flight plan route (green line) or deviate to left on blue track or right on yellow track line ?



Tick one of the choices below:

- ☐ Continue on flight plan (green line) as it is clear of weather cells
- ☐ Deviate to the right on yellow line as it reduces the time to destination, clears weather and reduces fuel required.
- ☐ Deviate to the left on blue line as it clears the weather on upwind side
- ☐ Continue on the flight plan (green line) as fuel status is critical.

4a. In the question directly above, how confident are you that the decision you have made is correct?

- ☐ Extremely
- ☐ Very
- ☐ Moderately
- ☐ Slightly
- ☐ Not at all

4b. In the question directly above, how confident are you that the outcome of your decision will be safe?

- ☐ Extremely
- ☐ Very
- ☐ Moderately
- ☐ Slightly
- ☐ Not at all

DECISION MAKING SURVEY

SECTION B--- DECISION MAKING WITH TIME LIMIT 10 MINUTES

5. Based on aircraft type you fly, assume you have taken off and are climbing on runway heading and passing 2000 ft. At this point you experience an all engine failure. What would be your decision ?

- ☐ Continue straight ahead and carry out ditching
- ☐ Continue a 180 turn on to reciprocal runway and land back
- ☐ Turn back towards runway and ditch closer to the runway
- ☐ Continue straight ahead and carryout ditching, if unsuccessful engine restart

5a. In the question directly above, how confident are you that the decision you have made is correct?

- ☐ Extremely
- ☐ Very
- ☐ Moderately
- ☐ Slightly
- ☐ Not at all

5b. In the question directly above, how confident are you that the outcome of your decision will be safe?

- ☐ Extremely
- ☐ Very
- ☐ Moderately
- ☐ Slightly
- ☐ Not at all

DECISION MAKING SURVEY

SECTION B--- DECISION MAKING WITH TIME LIMIT 10 MINUTES

6. You are in cruise in flight. You are navigating around a weather system on your route. Suddenly on your twin engine aircraft, one of the engine flames out (or on your 4 engine aircraft, two engines flameout) You now begin to carry-out the abnormal procedures and the engine relight occurs. You are still few hours away from destination. What would be your decision with respect to the continuation of the flight?

- ☐ Divert to the nearest suitable airport as the engine could quit again
- ☐ Divert to the nearest suitable airport as there could be regulatory implications
- ☐ Continue to destination as the engine has restarted
- ☐ Continue to the destination after engine restart ensuring alternates available en-route to divert if required

6a. Continue to the destination after engine restart ensuring alternates available en-route to divert if required

- ☐ Extremely
- ☐ Very
- ☐ Moderately
- ☐ Slightly
- ☐ Not at all

6b. In the question directly above, how confident are you that the outcome of your decision will be safe?

- ☐ Extremely
- ☐ Very
- ☐ Moderately
- ☐ Slightly
- ☐ Not at all

DECISION MAKING SURVEY

SECTION B--- DECISION MAKING WITH TIME LIMIT 10 MINUTES

7. During an abnormal event, how confident are you that you will be able to identify or get to the root of the problem and fix it?

- ☐ Extremely
- ☐ Very
- ☐ Moderately
- ☐ Slightly
- ☐ Not at all

7a. In the question directly above, how confident are you about the choice you made is correct?

- ☐ Extremely
- ☐ Very
- ☐ Moderately
- ☐ Slightly
- ☐ Not at all

7b. In the question directly above, how confident are you that the outcome of your decision making and problem solving will be safe?

- ☐ Extremely
- ☐ Very
- ☐ Moderately
- ☐ Slightly
- ☐ Not at all

DECISION MAKING SURVEY

SECTION B--- DECISION MAKING WITH TIME LIMIT 10 MINUTES

8. In the event of encountering a complex failure, say an engine failure coupled with landing gear damage and hydraulic fluid loss, on takeoff, how well are you equipped to utilize procedures optimally to address the situation?

- ☐ Extremely
- ☐ Very
- ☐ Moderately
- ☐ Slightly
- ☐ Not at all

8a. In the question directly above, how confident are you that the decision you have made is correct?

- ☐ Extremely
- ☐ Very
- ☐ Moderately
- ☐ Slightly
- ☐ Not at all

8b. In the question directly above, how confident are you that the outcome of your decision will be safe?

- ☐ Extremely
- ☐ Very
- ☐ Moderately
- ☐ Slightly
- ☐ Not at all

DECISION MAKING SURVEY

SECTION B--- DECISION MAKING WITH TIME LIMIT 10 MINUTES

9. Do you believe that applying decision making model helps crew to make better decisions irrespective of sufficient time available or not?

- ☐ Extremely
- ☐ Very
- ☐ Moderately
- ☐ Slightly
- ☐ Not at all

9a. In the question directly above, how confident are you that your decision making model application is correct?

- ☐ Extremely
- ☐ Very
- ☐ Moderately
- ☐ Slightly
- ☐ Not at all

9b. In the question directly above, how confident are you that the outcome of your decision will be safe?

- ☐ Extremely
- ☐ Very
- ☐ Moderately
- ☐ Slightly
- ☐ Not at all

DECISION MAKING SURVEY

SECTION B--- DECISION MAKING WITH TIME LIMIT 10 MINUTES

10. You are about to take off and lining up on the runway. You see weather on takeoff path about 7 miles ahead. What would be your decision with respect to the takeoff?

- ☐ Continue the takeoff and avoid weather after airborne by deviating
- ☐ Continue the takeoff as the weather is 7 miles away
- ☐ Consider taking off from reciprocal runway
- ☐ Consider takeoff and immediate turn away from weather

10a. In the question directly above, how confident are you that the decision you have made is correct?

- ☐ Extremely
- ☐ Very
- ☐ Moderately
- ☐ Slightly
- ☐ Not at all

10b. In the question directly above, how confident are you that the outcome of your decision will be safe?

- ☐ Extremely
- ☐ Very
- ☐ Moderately
- ☐ Slightly
- ☐ Not at all

DECISION MAKING SURVEY

SECTION B--- DECISION MAKING WITH TIME LIMIT 10 MINUTES

11. In the event of an emergency situation on board with safety impacted, to what extent do you agree with following statement: "Improvising appropriately when faced with unforeseen circumstances leads to achieving the safest outcome. "

- ☐ Extremely
- ☐ Very
- ☐ Moderately
- ☐ Slightly
- ☐ Not at all

11a. In the question directly above, how confident are you that the decision to improvise you have made is correct?

- ☐ Extremely
- ☐ Very
- ☐ Moderately
- ☐ Slightly
- ☐ Not at all

11b. In the question directly above, how confident are you that the outcome of your decision will be safe?

- ☐ Extremely
- ☐ Very
- ☐ Moderately
- ☐ Slightly
- ☐ Not at all

DECISION MAKING SURVEY

SECTION B--- DECISION MAKING WITH TIME LIMIT 10 MINUTES

12. To what extent do you agree to the following decision making indicator:

"When time available, I would consider as many options available as possible to the problem before zeroing on the best optimal option".

- ☐ Extremely
- ☐ Very
- ☐ Moderately
- ☐ Slightly
- ☐ Not at all

12a. In the question directly above, how confident are you that the decision to explore options for optimal solution you have made is correct?

- ☐ Extremely
- ☐ Very
- ☐ Moderately
- ☐ Slightly
- ☐ Not at all

12b. In the question directly above, how confident are you that the outcome of your decision will be safe?

- ☐ Extremely
- ☐ Very
- ☐ Moderately
- ☐ Slightly
- ☐ Not at all

DECISION MAKING SURVEY

SECTION B--- DECISION MAKING NO TIME LIMIT

13. You are in cruise and the cabin crew reports dense smoke coming out of airconditioning vents. Your colleague in the cockpit suggests to verify the actual source of fire and smoke and not jump to conclusions that it is an airconditioning smoke. Would you agree to your colleague's suggestion?

- ☐ Extremely
- ☐ Very
- ☐ Moderately
- ☐ Slightly
- ☐ Not at all

13a. In the question directly above, how confident are you that the decision you have made is correct?

- ☐ Extremely
- ☐ Very
- ☐ Moderately
- ☐ Slightly
- ☐ Not at all

13b. In the question directly above, how confident are you that the outcome of your decision will be safe?

- ☐ Extremely
- ☐ Very
- ☐ Moderately
- ☐ Slightly
- ☐ Not at all

DECISION MAKING SURVEY

SECTION B--- DECISION MAKING WITH TIME LIMIT 10 MINUTES

14. During take roll you experience a nose tire burst and confirm that later on climb out on systems page. At the same time, you notice that the left side main gear doors are stuck in open position. Your crew suggests to keep the landing gear down and get a visual pass over control tower to ascertain the extent of damage. Do you believe that by doing so, outcome of decision making is enhanced and lead to a safer outcome?

- ☐ Extremely
- ☐ Very
- ☐ Moderately
- ☐ Slightly
- ☐ Not at all

14a. In the question directly above, how confident are you that the decision you have made is correct?

- ☐ Extremely
- ☐ Very
- ☐ Moderately
- ☐ Slightly
- ☐ Not at all

14b. In the question directly above, how confident are you that the outcome of your decision will be safe?

- ☐ Extremely
- ☐ Very
- ☐ Moderately
- ☐ Slightly
- ☐ Not at all

DECISION MAKING SURVEY

SECTION B--- DECISION MAKING WITH TIME LIMIT 10 MINUTES

15. While cruising at FL280, you happen to encounter some weather. You resort to weather deviation as appropriate. While deviating, one of the engine flame out occurs (two engines for 4 engine aircraft). As per the aircraft procedures, the drills and checklist is carried out. What would be the crew actions going further with respect to decision making?

- ☐ Attempt engine restart as it could be due to weather, if successful, continue to the nearest suitable airport and land for investigation
- ☐ Attempt engine restart as it could be due to weather, if successful, continue to the nearest suitable airport as the restarted engine is still considered suspect.
- ☐ Do not attempt engine restart as engines being highly reliable, a restart could damage the engine further
- ☐ Attempt engine restart as it could be due to weather, if successful, continue to the destination if the engine parameters stay normal thereafter.

15a. In the question directly above, how confident are you that the decision you have made is correct?

- ☐ Extremely
- ☐ Very
- ☐ Moderately
- ☐ Slightly
- ☐ Not at all

15b. In the question directly above, how confident are you that the outcome of your decision will be safe?

- ☐ Extremely
- ☐ Very
- ☐ Moderately
- ☐ Slightly
- ☐ Not at all

DECISION MAKING SURVEY

SECTION B--- DECISION MAKING WITH TIME LIMIT 10 MINUTES

16. With the onset of an acrid smell and smoke in the cabin, crew of an aircraft decide to divert to the nearest airfield ten minutes away. They decide to hold to complete the checklist systematically before proceeding to land. How well has their decision contributed to maintaining safe operation?

- ☐ Extremely
- ☐ Very
- ☐ Moderately
- ☐ Slightly
- ☐ Not at all

16a. In the question directly above, how confident are you that the crew decision is correct?

- ☐ Extremely
- ☐ Very
- ☐ Moderately
- ☐ Slightly
- ☐ Not at all

16b. In the question directly above, how confident are you that the outcome of crew decision will be safe?

- ☐ Extremely
- ☐ Very
- ☐ Moderately
- ☐ Slightly
- ☐ Not at all

DECISION MAKING SURVEY

SECTION B--- DECISION MAKING WITH TIME LIMIT 10 MINUTES

17. You are taxiing for take-off with storm approaching the runway. You decide that you will be able to get airborne before the weather affects the take-off. As you near the take-off point, you decide to rush through the take-off to beat the weather onset. To what extent do you believe that when rushed, the ability to make better decision suffers?

- ☐ Extremely
- ☐ Very
- ☐ Moderately
- ☐ Slightly
- ☐ Not at all

17a. In the question directly above, how confident are you about the decision you have made is correct?

- ☐ Extremely
- ☐ Very
- ☐ Moderately
- ☐ Slightly
- ☐ Not at all

17b. In the question directly above, how confident are you that the outcome of your decision will be safe?

- ☐ Extremely
- ☐ Very
- ☐ Moderately
- ☐ Slightly
- ☐ Not at all

DECISION MAKING SURVEY

SECTION B--- DECISION MAKING WITH TIME LIMIT 10 MINUTES

18. You experience a hydraulic failure on departure. You assess that the flight can continue to destination and maintain schedule. Since there is no time pressure to land back, you decide to continue to destination as it is safe and optimal solution. To what extent do you agree to the above decision.

- ☐ Extremely
- ☐ Very
- ☐ Moderately
- ☐ Slightly
- ☐ Not at all

18a. In the question directly above, how confident are you that the decision made is correct?

- ☐ Extremely
- ☐ Very
- ☐ Moderately
- ☐ Slightly
- ☐ Not at all

18b. In the question directly above, how confident are you that the outcome of your decision will be safe?

- ☐ Extremely
- ☐ Very
- ☐ Moderately
- ☐ Slightly
- ☐ Not at all

DECISION MAKING SURVEY

SECTION B--- DECISION MAKING WITH TIME LIMIT 10 MINUTES

19. When you encounter a problem on flight, how do you currently deal with the decision making in solving the problem?

- ☐ Based on my experience
- ☐ Intuitively
- ☐ Utilising decision making model
- ☐ Mix of decision making process and intuitive based on situation
- ☐ Adhering to company and failure procedures and next course of action

19a. In the question directly above, how confident are you that the decision you have made is correct?

- ☐ Extremely
- ☐ Very
- ☐ Moderately
- ☐ Slightly
- ☐ Not at all

19b. In the question directly above, how confident are you that the outcome of your decision will be safe?

- ☐ Extremely
- ☐ Very
- ☐ Moderately
- ☐ Slightly
- ☐ Not at all

DECISION MAKING SURVEY

SECTION B--- DECISION MAKING WITH TIME LIMIT 10 MINUTES

20. You are flying in the vicinity of a weather system and carrying out weather avoidance. Experiencing light turbulence and icing conditions, you decide to deviate further. Suddenly you notice that one of the engines has flamed out.

You consider a diversion to nearby airfield. After the procedural flow, you decide to consider restart of the engine. You have a successful restart subsequently. Based on this new condition, would you consider reviewing the decision made on previous information and condition?

- ☐ Extremely
- ☐ Very
- ☐ Moderately
- ☐ Slightly
- ☐ Not at all

20a. In the question directly above, how confident are you that the decision you have made is correct?

- ☐ Extremely
- ☐ Very
- ☐ Moderately
- ☐ Slightly
- ☐ Not at all

20b. In the question directly above, how confident are you that the outcome of your decision will be safe?

- ☐ Extremely
- ☐ Very
- ☐ Moderately
- ☐ Slightly
- ☐ Not at all

* RECORD THE COMPLETION TIME HERE

Date / Time

hh	mm	-	↑ ↓
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Appendix B. Massey University Ethics Committee Approval letter



Date: 06 December 2017

Dear Srinivas Rao

Re: Ethics Notification - 4000018769 - INFLUENCE OF TIME ON DECISION MAKING IN AIRLINE PILOTS

Thank you for your notification which you have assessed as Low Risk.

Your project has been recorded in our system which is reported in the Annual Report of the Massey University Human Ethics Committee.

The low risk notification for this project is valid for a maximum of three years.

If situations subsequently occur which cause you to reconsider your ethical analysis, please contact a Research Ethics Administrator.

Please note that travel undertaken by students must be approved by the supervisor and the relevant Pro Vice-Chancellor and be in accordance with the Policy and Procedures for Course-Related Student Travel Overseas. In addition, the supervisor must advise the University's Insurance Officer.

A reminder to include the following statement on all public documents:

"This project has been evaluated by peer review and judged to be low risk. Consequently, it has not been reviewed by one of the University's Human Ethics Committees. The researcher(s) named in this document are responsible for the ethical conduct of this research."

If you have any concerns about the conduct of this research that you want to raise with someone other than the researcher(s), please contact Dr Brian Finch, Director - Ethics, telephone 06 3569099 ext 86015, email humanethics@massey.ac.nz.

Please note, if a sponsoring organisation, funding authority or a journal in which you wish to publish requires evidence of committee approval (with an approval number), you will have to complete the application form again, answering "yes" to the publication question to provide more information for one of the University's Human Ethics Committees. You should also note that such an approval can only be provided prior to the commencement of the research.

Yours sincerely

Research Ethics Office, Research and Enterprise

Massey University, Private Bag 11 222, Palmerston North, 4442, New Zealand T 06 350 5573; 06 350 5575 F 06 355 7973
E humanethics@massey.ac.nz W <http://humanethics.massey.ac.nz>

Human Ethics Low Risk notification

Dr Brian Finch
Chair. Human Ethics Chairs' Committee and Director (Research Ethics)

Research Ethics Office, Research and Enterprise

Massey University, Private Bag 11 222, Palmerston North, 4442, New Zealand **T** 06 350 5573; 06 350 5575 **F** 06 355 7973
E humanethics@massey.ac.nz **W** <http://humanethics.massey.ac.nz>

Appendix C. Guidelines for conducting the survey on site

Guidelines for conducting the Decision Making Questionnaire

1. There are 2 sets of decision making questionnaire provided labelled as:
 - SET 1 and SET 2
 - Each SET has SECTION A and SECTION B
2. The questionnaire sections **A** labelled *Opinion on Decision Making Skills* containing 11 questions and section **B** labelled *Decision making (post-test) containing 20 questions respectively*
3. Half of the pilots taking the test may be given SET 1 and the other half SET 2
4. SET 1 has no time limit for answering both sections A and B.
5. SET 2 section B has a time limit of 10 minutes.
6. Kindly ensure to brief the pilots answering SET 2 to finish the first section A and wait for the invigilator to start the time limit of 10 minutes for section B.
7. It is important for the invigilator to brief the pilots and start the section B of SET 2 together for the group to time it.
8. If the group under time limit is crossing the 10 minutes limit, they may be allowed to continue to finish. The invigilator can provide time countdown at 5 minutes to go and 3 minutes to go and then once time is up announce “time limit is up, please finish as fast as you can”. The idea being to make them complete the questionnaire under time pressure.
9. Crew flying two aircraft type may mark both types, for example A320 and A330, may mark both types.

10. The invigilator notes the time taken for each participant for Section B of SET 2 and write down on the first page of questionnaire
11. Ensure half the participants does the SET 1 with no time limit and other half do SET 2 with time limit on section B.
12. Ethical guidelines of Massey University are adhered to in this process and the participants only record demographic data.
13. Participants may be given brief that this is a research into understanding decision making and that there is no right or wrong answer.
14. Participants may be left alone to answer the questionnaire and no specific suggestion or reference to answering the questions be done.
15. Request kindly print the approval letter to conduct this survey and keep it handy should someone query if the company has granted permission to carry out the same.

Thank you for strictly adhering to these guidelines as it helps the participant airlines to enhance training effectiveness and flight safety.

Appendix D. Access letter requesting permission to conduct research

Capt. Srinivas Rao

School of Aviation

Massey University

New Zealand

To

**SUB: ACCESS LETTER REQUESTING PERMISSION TO CONDUCT
RESEARCH**

Dear _____,

Greetings to you

I am on A320/A330 fleet as senior examiner with Etihad Airways doing my Masters at the School of Aviation, Massey University, New Zealand and propose to carryout research thesis under the supervision of Dr Andrew Gilbey. Dr Gilbey has conducted most of his research in applied aviation psychology, involving pilot decision-making. My research involves studying decision making of pilots under time constraints. For this study, we propose to present groups of pilot's different scenarios requiring decision making by subjecting one group under time pressure and the other group provided ample time. This study is spread across airlines which utilize decision making models and as well as the ones which do not. The research may provide feedback as to how the decision making by pilots is effected under time pressure. The effects on course of action by pilots could possibly be also studied.

If Etihad agrees to participate in the research, I plan to conduct 40-60 surveys of pilots in total, split into two groups. Ideally, the participating voluntary crew will come from different fleets in your

organization, from relatively lower to relatively higher experience levels.

The name of your organization and all individual participants will be kept confidential, unless you (and they) explicitly give permission for identities to be revealed. You have the right to ask questions about this research study and to have those questions answered by me before, during or after the research. All ethical compliance of your company will be strictly adhered to.

I will also provide the detailed information about the research, ethics clearance from Massey University, and the proposed survey upon your finalization of the methodology for the research. This would be sent as a PDF file by email. Should you decide that your airline is willing to participate in the research, I ask you to kindly sign in the consent form attached.

Should you require any further information, please do not hesitate to contact me. My contact details are as follows:

Srinivas Rao

Email [REDACTED]

Mobile: [REDACTED]

Upon completion of the study, I undertake to provide you with an electronic copy of the thesis.

To provide consent of your airline and the pilot participation voluntarily, kindly return the attached sample format on your airline letter-head to the email address furnished above. Your permission to conduct this study will be greatly appreciated.

Thanking you

Yours sincerely,

(Capt. Srinivas Rao)

Appendix E. Permission letter to conduct research from Etihad Airways



Ref: GCAA/5326/MM/sc

Date: 04th Nov 2018

From: Capt. Majed Al Marzouqi,
Vice President Fleet Operations
Etihad – UAE

Dear Capt. Srinivas,

Trust this email finds you well.

There is no objection from Etihad to conduct the research. However, please ensure your adherence to the following:-

- All respondents should be volunteers. I suggest that a request should be sent from management of your regular communications channel. It should state that the research is being conducted independently of EY as part of the university programme and that we will not have access to details of the interviews or any personal information.
- The employee must obtain explicit consent to conduct the research from each respondent.
- The employee conducting the research must adhere strictly to EAG's privacy (use your email username and password to download the document) principles when conducting the research and must present each respondent with a short statement explaining how the data will be used, stored and who it will be shared with.

Finally, it would be a good idea for you to share knowledge of the aggregated findings of your research in case it is of benefit to Etihad.

I wish you all the best.

Yours sincerely,
For Etihad Airways,



CAPT. MAJED AL MARZOUQI
VICE PRESIDENT FLEET OPERATIONS

P.O. Box: 35566, Abu Dhabi, United Arab Emirates
Tel: +971 2 511 0000 Fax: +971 2 511 2000
National Airline of the United Arab Emirates



ج.ب. 35566، أبوظبي، الإمارات العربية المتحدة
هاتف: +971 2 511 0000 ، فاكس: +971 2 511 2000
الخطوط الوطنية لحولة الإمارات العربية المتحدة

Appendix F. Permission letter to conduct research from Jet Airways



16th August, 2017

Capt. Srinivas Rao,
704, Delma S. Building,
Al Nahyan Camp,
Delma Street,
Abu Dhabi,
U.A.E.

Dear Capt. Srinivas,

On behalf of Jet Airways (India) Limited, I am writing to formally indicate our awareness of the research proposed by you and Dr. Gilbey of Massey University, as part of your research thesis study. We are aware that you intend to conduct this research by administering a questionnaire/scenario problems to the voluntary participating Pilots.

As Sr. Vice President – Flight Operations, I grant permission to conduct your research at our Organisation.

If you have any questions or concerns, please feel free to contact the following personnel :

Mr. Shreekant Bhagwat	Tel. 6121 1439	eMail: sbhagwat@jetairways.com
Capt. J.S. Krishna	Mob. 91766 23609	eMail: jskrishna@jetairways.com

Regards,

Yours sincerely,

Capt. Sudhir Gaur
Sr. Vice President
Flight Operations

Jet Airways (India) Limited

Registered Office : Siroya Centre, Sahar Airport Road, Andheri (East), Mumbai - 400 099, India. Tel +91 22 6121 1000 Web www.jetairways.com

CIN: L99999MH992PLC066213

Appendix G. Permission letter to conduct research from Air Seychelles



PERMISSION LETTER TO CONDUCT RESEARCH

19th September 2017

Srinivas Rao

704 Delma S Building

Al Nahyan camp

Delma Street, Abu Dhabi

U.A.E

Dear Capt Srinivas,

On behalf of Air Seychelles, I am writing to formally indicate our awareness of the research proposed by you and Dr Gilbey of Massey University, as part of your research thesis study. We are aware that you intend to conduct this research by administering a questionnaire/scenario problems to the voluntary participating pilots.

As General Manager Operations I grant permission to conduct your research at our organization.

If you have any questions or concerns, please feel free to contact my office at +2482636263 and also via email at Dyoung@airseychelles.com.

Sincerely,

A handwritten signature in blue ink that reads "Donal Young".

Donal Young

General Manager Operations

19th September 2017



Appendix H. Permission letter to conduct research from Arik Air



Our Ref: ARIK-QD/MISC/60/08/2017

Ikeja, Lagos
August 1, 2017

Srinivas Rao
704 Delma S Building
Al Nahyan camp
Delma Street, Abu Dhabi
U.A.E

PERMISSION LETTER TO CONDUCT RESEARCH

Dear Capt. Srinivas

Reference is made to your request on the subject.

On behalf of Arik Air Ltd, I am writing this to formally indicate our awareness of the research proposed by you and Dr. Gilbey of Massey University, as part of your research thesis study. We are aware that you intend to conduct this research by administering a questionnaire/scenario problems to the voluntary participating pilots.

As Vice President Quality assurance, I hereby, grant permission to conduct your research at our organization.

If you have any questions or concerns, please feel free to contact my office at +234 80 777 92549 and also via email at gopal.mohan@arikair.com.

Accept assurance of our highest cooperation,

Sincerely,

A handwritten signature in black ink, appearing to read "G. R. Mohan".

Capt. Gopal R Mohan
Vice President, Quality assurance



Arik Air Ltd (in Receivership), Arik Air Aviation Centre, Murtala Muhammed Domestic Airport, P.O. Box 10468 Ikeja, Lagos, Nigeria

Tel: +234 (0) 1 2799900 Fax: +234 (0) 1 2799391/2 Email: info@arikair.com Web: www.arikair.com
Registered company 601023

Receiver: Oluseye Opasanya, SAN

Appendix I. List of Participating Pilots' Airlines

LIST OF PARTICIPATING PILOTS' AIRLINES

AIR ARABIA	KOREAN AIRLINES
AIR ASIA INDIA	QANTAS AIRLINE
AIR INDIA	QATAR AIRWAYS
AIR NEW ZEALAND	ROYAL NEPAL AIRLINES
AIR SEYCHELLES	RWANDA AIRWAYS
ARIK AIR	SALAM AIR
ASIANA AIRLINES	SAUDIA AIRLINES
BEIJING CAPITAL AIRLINES	SCOOT
BLUE DART	SILKAIR
BRITISH AIRWAYS	SINGAPORE AIRLINES
CHINA SOUTHERN	SPICEJET AIRLINES
EMIRATES AIRLINE	SRILANKAN AIRLINES
ETIHAD AIRWAYS	STOBART AIR
FIJI AIRWAYS	TIGER AIRWAYS
GO AIR	VIETJET AIRLINES
GULF AIR	VIRGIN AIRLINES
INDIGO	VIRGIN ATLANTIC
JET AIRWAYS	VISTARA AIRLINES