Massey University

Situational Awareness of Pilots in the Cruise

A Thesis by Nicholas Vincent

Submitted as partial fulfilment of the requirements for the degree of Masters of Aviation at Massey University Palmerston North New Zealand

Abstract

Situational Awareness is a corner stone of flight safety; a flight crew or single pilot must be situationally aware to allow the flight to operate without incident and to detect any failure or faults as soon as practically possible. This gives pilots the greatest length of time to respond and then either resolve the issue, or minimize escalation. This research explores whether the implementation of a checklist is beneficial during a portion of the flight when there is low outside stimulation for the pilot. The research takes a practical approach, attempting to find not just an effect but a meaningful effect that could potentially improve safety in a real-world scenario. In accordance with this, Fisher's significance testing is used, and while the results are statistically interpreted using this method, Bayes factors are also used in an attempt to provide a more relevant answer to the research's endeavor to find a way to meaningfully increase flight safety.

Acknowledgements

This thesis would not be possible without the support of my supervisor Dr Jose Perezgonzalez who believed in my research, gave me helpful suggestions, edited multiple drafts and ensured that this work was up to standard. Without his support, the finished product you see before you would have been unobtainable.

A special appreciation goes to all the flight schools and pilots who allowed me to conduct my research and took part, the experiment could never have been run without their support and help.

I would also like to thank Mieke and Scott for doing their editing input, working through portions and drafts until the information gathered matched the thought processes in my head.

To Nigel, Les, Esme, Kevin and Kathy who supported me through this task, who were the first testers of the experiment and gave me the inspiration to continue and work harder than ever.

To the rest of my family who have unknowingly given me support to complete this thesis and guidance when I needed it, their aid in reducing other workloads to allow concentration on my thesis has been a massive boon.

Finally, to my wife Lydia who has waited patiently for me to complete this undertaking. her support has made this possible, when I was struggling she would give me the inspiration I needed to keep going and finish this long process, especially when life was getting very busy. She has truly made this possible with her support and love.

Contents

Chapter 1

Introduction

1.1 Introduction

Situational Awareness (SA) in the cockpit is a vital part of flight safety and efficiency. The Situational Awareness exhibited by the flight crew of an aircraft works to keep the aircraft flying in the most efficient way possible, keeping the aircraft on track and ensuring that all procedures are taken into account and future events are planned for. This efficiency allows the aircraft to be operating for the most profit, or minimalized cost, in a commercial situation. This Situational Awareness also extends to the safety of the aircraft. The ability to identify failures and changes from the expected while in flight is a large part of its safe operation, allowing more time to react to a situation and more time for the crew in a high workload situation. Situational Awareness is important to aviation and therefore increasing it would be valuable.

The research was based on the idea of increasing the Situational Awareness in the cockpit. It used a newly designed checklist to increase a pilot's SA, compared to pilots not using the checklist. This paper will also review Situational Awareness itself, and break it into its various components to define it and identify areas that can be improved in flight. The checklist will be designed to increase SA in those identifiable areas.

A cost-effective way to conduct the experiment was developed, taking into account the portability required that would allow for the application of the experiment to be transported around the upper and mid North Island of New Zealand, to reach flight schools in those areas.

Also taken into account was the practicality of allowing for minimal cost to simulate an inflight situation.

The overall research hypothesis is that the checklist has a positive result on the Situational Awareness of pilots.

Chapter 2

Literature Review

2.1 Situational Awareness

Defining Situational Awareness

Situational Awareness as a concept was identified during World War 1 by Oswald Boelke who realized the importance of gaining an awareness of the enemy before the enemy gained a similar awareness (Stanton, Chambers, & Piggott, 2001). While this original concept is not wholly applicable in commercial aviation due to the absence of enemy aircraft, the importance of gaining and maintaining awareness as a pilot or flight crew to complete a flight safely and efficiently is vital to aviation.

Research from the Australian Transportation Safety Board indicates approximately 85% of incident reports include a mention of loss of situational awareness (AirBus, 2007). This statistic shows the importance of the concept and why any increase would be beneficial to the industry. The Airbus report both supported and reiterated this statistic, stating that Situational Awareness is essential for flight safety.

Situational Awareness has many similar definitions; it has been defined as having an accurate understanding of what is happening around you and what is likely to happen in the near future (AirBus, 2007). Another similar definition is the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning and the projection of their status in the near future (Endsley, 1999). These definitions give a reader the indication that

Situational Awareness refers to understanding the environment that a user or operator is in, and anticipating any potential changes in that environment.

Situational Awareness can be said to have three levels; level one being the perception of the elements in the environment, level two being comprehension of the current situation and level three projection of the future status (Endsley, 1999). Taking these into account Stanton, Chambers, & Piggott (2001) took different authors' definitions and combined them with the below model to describe how SA relates to the real world and what is going on around the aircraft; as they put it, simply the interaction between the person and the world:

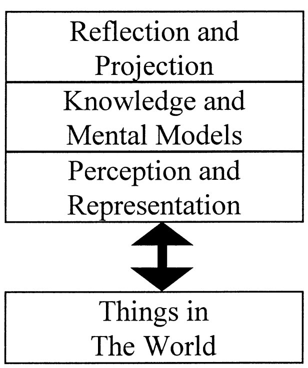


Figure 1: Systems approach to Situational Awareness (Stanton, Chambers, & Piggott, 2001)

Figure 1 illustrates the integration of Situational Awareness definitions into a systems approach, or how the three levels of SA combine with things in the world (Stanton, Chambers, & Piggott, 2001).

Situational Awareness affects decision making as well as an operator's goals, objectives and preconceptions (AirBus, 2007). This statement reveals the real importance of SA; the motivation behind the decisions and thus the knowledge gained is the key advantage of having an increased amount of SA. Decisions, and the ability to make informed and timely decisions, can be the difference between a small course correction and a catastrophe in flight. An example of this could be, while operating under Visual Flight Rules (VFR), a pilot must be aware of their positioning; a lookout is a vital part of this process. A lookout can give a pilot a perception of where the aircraft is in the world, and this information, when added to other perceptions, increases comprehension of a current situation and projection of future events, thus giving the pilot Situational Awareness. An example of a decision that may potentially be made in this situation could be avoiding adverse weather; the lookout gives the pilot perception of the weather, knowledge tells the pilot how severe the weather phenomena is, prior knowledge and experience gives the pilot the ability to project options for avoiding the weather and the consequences that would result. All this information gives the pilot Situational Awareness of the real world and allows pilots to make a safe and efficient decision.

While these definitions are very technical, a simple definition can be defined as knowing what is going on around you (Endsley, 2000). Taking into account knowledge and experience, and adding this to what can be seen and felt in order to achieve a goal, is what constitutes Situational Awareness. The achievement of a goal in commercial aviation is the execution of an efficient and safe flight to the desired destination. Goals are central to the development of Situation Awareness (Endsley, 2000).

“Staying ahead of the aircraft” is a term widely used in the aviation industry; this term refers to the ability of the pilot, or flight crew to anticipate and respond to future events (Rankin, Woltjer, Field, & Woods, 2013). The application of this allows the flight crew to not only see what is happening but also what is going to happen to the aircraft, and therefore reducing the likelihood of potential surprises. An example of this would be looking through the airport plate of the destination aerodrome. An airport plate or aerodrome chart gives a pilot information about an airdrome. This includes information such as runway headings, altitude of the runways, landing and take off procedures. The study of these allows a pilot to familiarize themselves with the upcoming airport as well as any special procedures and pre-setting any radio frequency changes. This reduces the build up of tasks at a time when workload is potentially much higher. This example and others assist in the flight crew's ability to increase efficiency and safety.

As stated, Situational Awareness in part is about participation of what is likely to happen in the near future, therefore it could be said that an increase in Situational Awareness assists the flight crew in staying in front of the aircraft. For example, tasks such as:

- Setting radio frequencies on alternate radio units in preparation for a change in radio calls.
- Preparing a radio call to ensure it is verbalized clearly over the radio to the intended recipient (this is practically helpful when operating in unfamiliar locations).
- Completing a checklist early where applicable, to reduce workload at a heavy workload portion of the flight.

These examples are just three ways that workload can be reduced in future and therefore result in less pressure being applied to the pilot, especially in critical moments of flight. This is all done to minimize the effect of a surprise if one occurs, a surprise occurring when a mismatch between what is observed and what is expected is detected (Rankin, Woltjer, Field, & Woods, 2013). In a real-life scenario, a surprise would require an appropriate response; either an acknowledgement, an alternative found, or an emergency action taken. This response would depend on how critical the surprise is; this can vary from a fuse popping inflight requiring it to be reset, to a complete engine failure requiring quick and decisive action to start the emergency procedures, in order to either get the engine operating again or find a suitable emergency landing area. With regard to the research hypothesis, anything that would increase SA would ideally increase the chances of the discovery of a surprise and do so in a timely manner. This then imparts upon the pilot the knowledge already determined previously as a key component to making an informed decision. This anticipation of future tasks comes from a pilot's Situational Awareness; being aware of future tasks that are coming up shows a pilot's anticipation for future events.

Therefore, a device such as a checklist, that increases Situational Awareness, could potentially increase flight safety. It must be noted that a checklist must not distract from Situational Awareness; as performing a checklist instead of flying the aircraft could in fact reduce SA, especially in high workload portions of the flight.

2.2 Other areas of Situational Awareness

Situational Awareness can be broken down into other areas, such as Geographical SA, which includes the location of the aircraft, terrain, airports, cities and other prominent geographical landmarks known to the flight crew (Endsley, 1999). For the flight crew, being able to decipher what geographical landmarks are present is important and emphasized; also important is deciphering those that are not needed and that can be safely ignored.

Environmental SA is about the pilot knowing the location and severity of weather phenomena; VFR vs IFR conditions (Instrument Flight Rules), storm cells, freezing levels and amount of icing. This is important when deploying anti-icing countermeasures. Icing can be a fatal issue in aviation, the NTSB gave five examples of fatal accidents due to complications with icing. Pilots' SA could have been called into question with all examples (NTSB, 2011). Flying into icing conditions and not deploying anti-icing counter measures was a factor that could suggest evidence that there was a lack of SA on the flight deck.

Spatial/Temporal SA deals with the aircraft and the forces acting on the aircraft itself. These include attitude, altitude, heading, vertical speed and G-forces, as well as others. The knowledge of a pilot or flight crew to understand these factors is vital for safety and efficiency of the flight. Knowing how these affect the human element onboard the aircraft can be attributed to this area, while other parts such as Tactical SA and System SA also take into account how the aircraft is acting in the environment around it. The humans on board the aircraft must also be taken into account as part of Situational Awareness, in understanding the limits of the human pilots and what is recommended and what is possible. Positive G forces can reduce blood and oxygen flow to the brain, thereby reducing cognitive function (Department of The Airforce, 2014). A reduction in brain function could lead to a reduction in SA; this does not include the effect it could have on passengers, especially if they are not accustomed to the higher G forces that can be achieved in an aircraft. While it is imperative that increased and decreased G forces be accounted for in commercial aviation, in military aviation they are deemed to be an every-day consideration, especially in aircraft such as fighter jets.

Tactical SA deals with the identification of statuses and flight dynamics of other aircraft, comparing this to the capabilities of the aircraft the flight crew is operating. This area deals mainly with one aircraft being operated in an environment and how that compares in performance capabilities and technical capabilities to the aircraft and situation it is being operated in.

System SA involves the systems of the aircraft statuses, ensuring that they are functioning and are on the correct settings. This includes the settings of radio, altimeter and transponder equipment. This also deals with malfunctions, system performance, and flight safety, for example amount of fuel and the flight time that is afforded to the aircraft (Endsley, 1999). System SA could also be dealing with the functionality of all the instruments; the experiment as described and for the purpose of this thesis investigation will be creating failures in aircraft systems, therefore System SA holds relatively greater importance in this experiment when compared to the other areas of Situational Awareness. Given the diversity, situational awareness future research could be focused on these other areas. For example, an environmental SA research project could be focused on weather phenomena and icing conditions.

From all the above material, Situational Awareness in the aviation environment can be defined as the knowledge of the pilot or flight crew in the current environment, with respect to what has passed, for example experience, and what in future can be projected. The successful application of this knowledge can therefore be used in turn to increase SA, as shown in concepts such as "staying ahead of the aircraft". What this shows us can be illustrated as follows:

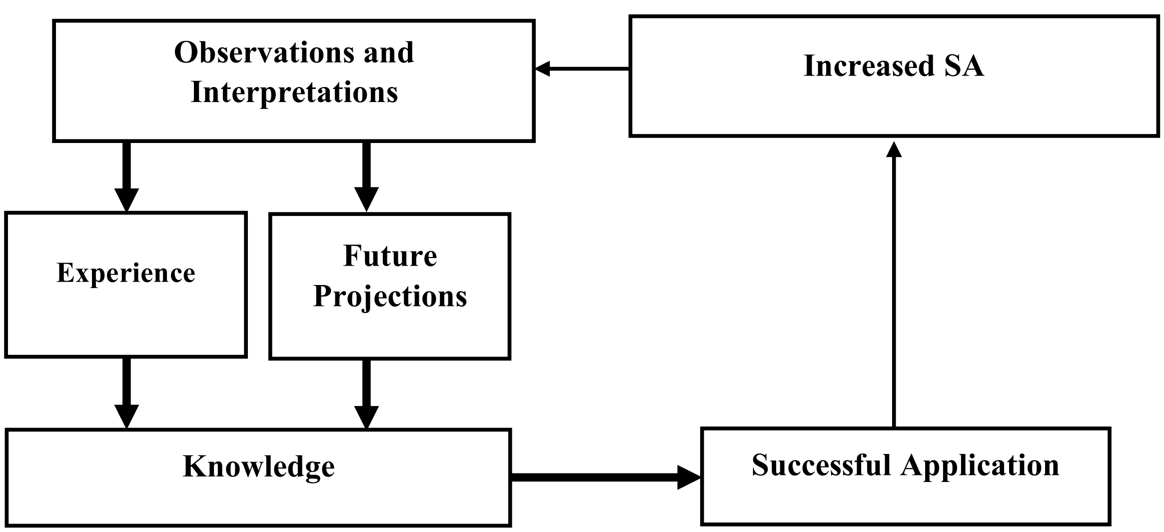


Figure 2: Conceptual Representation of the Phenomenon of "Staying Ahead of the Aircraft".

As shown, the development and continual application of SA can be seen as a cyclical process; as Observations and Interpretations of the real world occur, these can then be interpreted with the addition of experience, which in turn leads to the development of future projections. This gives the knowledge required, and the successful application of such knowledge results in an increase in Situational Awareness. This in turn provides a better understanding of alertness to the observations and interpretations of what is going on in the real world.

2.3 Individual Effects on Situational Awareness

Central to Situational Awareness in the cockpit in general is the individual. Endsley (1999) identified attention and working memory as two of the main factors that can affect an individual's level of SA.

Attention deals with the allocation of cognitive resources to prioritize incoming information, in order to bring the crew to a conscious state, update a scene model, update memory, and influence behavior (Mancas, 2016). Endsley (1999) stated that direct attention is needed for perceiving and processing the environment to form Situational Awareness, for selecting actions and executing responses. The limitation of a pilot's attention can include being overloaded or the poor prioritization of information. This could then lead to attention being deferred from areas of priority to areas of little importance.

Working memory refers to the temporary storage of information in connection with performance of other cognitive tasks such as reading, problem-solving or learning (Baddeley, 1983). Endsley

(1999) discussed working memory with the second level of SA and the comprehension of meaning coming from the data perceived, and the third level of SA drawing from working memory to project future status and make appropriate decisions. Therefore, a high tax on this temporary storage of information from one or both of these levels of SA could show in a reduction of SA.

An example where both levels of SA could become taxed is when approaching a busy aerodrome; a pilot's process of receiving radio calls from Air Traffic Control (ATC), looking out for other air traffic, reviewing approach procedures and setting up the aircraft for approach and landing must all be done safely and efficiently. This level of information processing would draw heavily on a pilot's working memory and attention, and could therefore reduce SA overall.

When workload is high and exceeds maximum human capacity, this does not necessarily mean that SA is at risk (Endsley, 2000). This level of high workload taxes both Working Memory and Attention Situational Awareness, which can cause both to suffer. Some authors suggest a tradeoff between workload and SA (Wickens, 2008). High workload, however, is not the only way workload can have a detrimental effect on SA; low workload can also reduce SA. Attention could be prioritized poorly in low workload portions of flight.

Workload can be defined as the cost incurred by an individual, given their capacities, while achieving a particular level of performance on a task with specific demands (DiDomenico & Nussbaum, 2008). There are two primary components of workload, with aspects either falling into the physical or mental category. Mental workload is the main focus in aviation when dealing with pilots and flight crew. Mental workload can be roughly defined as the ratio between task demands and the capacity of the operator (Veltman & Gaillard, 1996)**.** The concepts of Attention and Working Memory can be likened to mental workload; both being stretched in high mental workload situations. Under high mental workload operators have to invest more mental effort in order to maintain an adequate level of performance (Veltman & Gaillard, 1996). This effort is partly made up of Working Memory, in combination with the concept of subjective workload. Subjective workload assessments are based on an individual's personal feelings and perceptions, and require the individual to provide judgments of efforts that are associated with performance of a task or combination of tasks (DiDomenico & Nussbaum, 2008). Subjective workload can be likened to the direction of attention by an operator or in the aviation system, a pilot. Deciding where to put their attention and therefore their workload is important in the increase of Situational Awareness.

The overtaxing due to high workload of a pilot's capacities is not the only detrimental effect workload can have on SA. AIRBUS, (1995) found that alertness decrements concurred with flat workload, in other words when there is a limited amount of workload, for example during the cruise section of flight, resulting in reduced pilots' alertness. Boeing, (2016) reported that from 2007 through to 2016 11% of all fatal commercial aviation accidents occurred in the cruise section of flight, third highest behind final approach and landing with 24% each. This 11% was coupled with the estimation that 57% of all flight time consists of the cruise section of flight. Evidence suggests that as the largest section of flight operations and third highest area of fatal accidents, and acknowledging that up to 85% of accidents are caused by a loss in situational awareness; this area of low workload could prove to be an area of concern for commercial aviation. While the reduction of workload would lead to a higher level of SA, too much reduction would have the opposite effect. This could be likened to the Arousal Curve; too much and too little arousal or workload in this example can both have the effect of reducing SA.

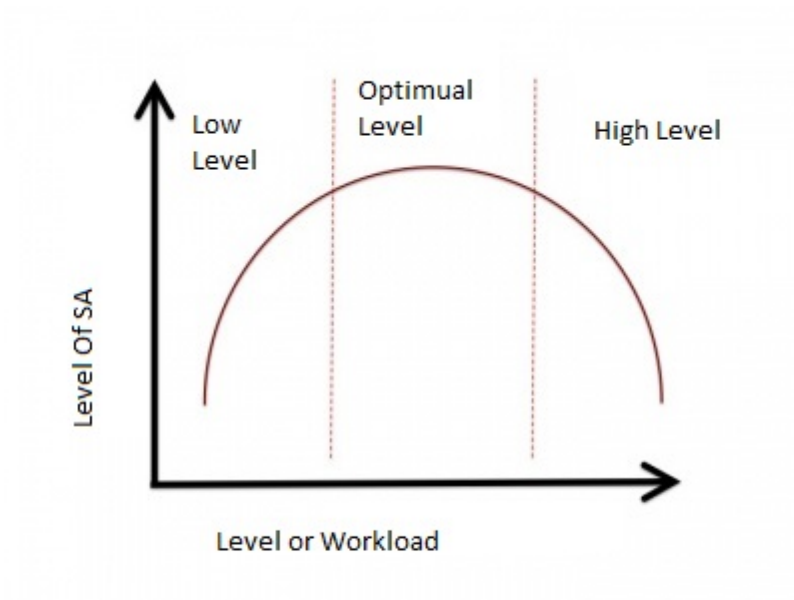


Figure 3: Workload compared to Situational Awareness on the Yerkes-Dodson Performance/Arousal Curve (Skybrary, 2016) .

Different areas of a flight can be applied to this curve; for example, descent and landing would be at the higher level of Workload, however cruise would be at the lower level. Instruments such as automation and checklists aid in the reduction and distribution of workload in these areas of high workload and low SA, but automation can have the same effect of reducing workload in apparent lower workload areas. High levels of automation could produce low workload conditions, leading to human error in abnormal conditions requiring immediate human intervention (Byrne, et al., 2008). This low workload condition can cause the opposite effect than that desired; it therefore cannot be forgotten that the increase of the workload in sections of the flight would be beneficial as well.

2.4 Automation

Automation is a large component of current aviation; USA Today asked a Commercial Pilot how much of a flight was controlled by the autopilot. The answer was, over 90% of most flights of a commercial airline flight is controlled by autopilot (USA Today, 2014). While the pilots do control the autopilot, this does have an effect on Situational Awareness of flight crews. Automation can be defined as “The technique of controlling an apparatus, a process or a system by means of electronic and/or mechanical devices that replaces the human organism in the sensing, decision-making and deliberate output” (Chialastri, 2012). Automation can impact pilots’ Situational Awareness in three main ways; changes in vigilance and complacency associated with monitoring, the assumption of a passive role instead of active role in controlling the system, and changes in the quality or form of feedback provided to the human operator (Endsley, 1996).

2.5 Checklist

Endsley, (1996) proposed that one way to minimize the negative effects of automation was to devise schemes that keep the human actively involved in the decision-making loop. A checklist is such a device that could be used to increase a pilot’s activity and remove them from a passive role.

A checklist in aviation is used to ensure that the crew will, or has, properly configured the aircraft for any given segment of flight (Degani & Wiener 1993). Degani & Wiener (1990) gives the following objectives for a checklist:

1. Aid the pilot in recalling the process of configuring the plane.
2. Provide a standard foundation for verifying aircraft configuration that will defeat any reduction in the flight crew's psychological and physical condition.
3. Provide convenient sequences for motor movements and eye fixations along the cockpit panels.
4. Provide a sequential framework to meet internal and external cockpit operational requirements.
5. Allow mutual supervision (cross checking) among crew members.
6. Enhance a team (crew) concept for configuring the plane by keeping all crew members "in the loop".
7. Dictate the duties of each crew member in order to facilitate optimum crew coordination as well as logical distribution of cockpit workload.
8. Serve as a quality control tool by flight management and government regulators over the pilots in the process of configuring the plane for the flight.

A checklist is used in all parts of modern day aviation, from engine start up to pre-landing checklists, to ensure all the above objectives are fulfilled to keep the aircraft and crew efficient and safe. Their proper use is imperative as the Federal Aviation Administration (FAA) found that of accidents that occurred during takeoff 60% included uninitiated or inadequately performed checklists (FAA, 1995).

Checklists themselves can be a distraction (Degani & Wiener, 1993). Designed to be a safety procedure, a checklist can lessen the safety of a flight and this must be taken into account. Also, the purpose of adding another checklist must be to improve safety more than it would hamper it. The design of a checklist is of vital importance as the FAA issued an entire report on the proper way to design them (FAA, 1995). Degani, Wiener, (1990) reported that with a longer checklist, pilots complained about inadvertently skipping items. This skipping of items on a checklist could lead to complications later in the flight, potentially hampering one of the eight objectives of a checklist. Given this information, checklists must be designed properly and any checklist implemented cannot be a distraction from Situational Awareness and safety.

A checklist that would potentially increase workload on a pilot in a low workload area could prove useful in providing evidence for the research hypothesis. Endsley (1999) found that not only high workload but low workload would produce poor SA. A checklist could refresh the cyclical SA process, serving to bring a pilot back into the optimal level of workload for SA in a low workload/highly automated situation. This ensures the observation interpretation process is accurate, with attention in the correct areas and the rest of the process flowing on.

2.6 Variables that can Affect Situational Awareness

2.6.1 Experience

Experienced Pilots may use their long term memory stores in the form of mental models to cope with the limits outlined above, namely limitations in working memory and attention (Endsley, 1999). These mental models allow for integration and comprehension of situations allowing for decision making without complete information being gained (Endsley, 1999). Experience can give pilots the mental modeling coping mechanism, therefore higher experience could potentially lead to higher SA.

2.6.2 Fatigue

Fatigue can be the cause or partial cause of human error (Manning, Rash, LeDue, Noback, & McKeon, 2004). The FAA reported that 21% of the reports in the aviation safety reporting system were associated with fatigue (Ji, Lan, & Looney, 2006). Sleep has been the most recognized factor when dealing with fatigue, and a lack of sleep has been shown to degrade all aspects of functioning including cognitive aspects of human performance (Ji, Lan, & Looney, 2006). Given the detrimental impact of fatigue on cognitive function alone, with the flow on effects on attention span and working memory, it is clear that this could develop into an impact on all forms of Situational Awareness.

2.7 Research Objectives

With the information presented, the goal of the research is to attempt to find a way to increase Situational Awareness of pilots in low workload portions of a flight. For example, in the cruise portion of a flight workload is lower especially when there are greater periods of time between changes in the flight, (i.e., heading changes or reaching top of decent). An increase to Situational Awareness in this area could have benefits to the greater aviation, aiding in the discovery and prompt resolution of issues before they can potentially risk both the plane and crew.

A checklist could be a tool to accomplish this, the aim being to increase workload and therefore increasing Situational Awareness. The act of completing a checklist could result in bringing the level of workload on the pilots into the optimum level exhibited above, with the resultant effect of increasing their overall Situational Awareness during the cruise stages of flight.

Chapter 3

3.1 Experiment

The experiment was designed to test pilot's levels of Situational Awareness. This was tested with a simulated flight; SA was measured using a questionnaire asking the participants questions that would give a score to their level of SA (See Appendix A). The experimental group was given a checklist to perform during the flight and the control group was not.

Methods

3.2 Participants

The participants were 46 pilots gathered from flight schools around the North Island of New Zealand, convenience sampling was the method used to gather participants. Flight schools provided clusters of potential participants of varying levels of experience. These participants were asked if they would like to volunteer to do the experiment. The experiment was ten minutes in duration, with a questionnaire portion afterwards.

3.3 Materials

The instruments used for the experiment were a laptop with Flight Simulator X installed. Flight Simulator was used as the most cost-effective way to bring participants into a virtual cockpit and allowed for the necessary mobility required to visit different flight schools around the North and central North Island of New Zealand. It also provided short set up and pack down times, to ensure that activities at the voluntary flight schools would be disrupted as minimal as possible. An Apple Ipad was issued to display Westport aeronautical plate information for the participants. The schools who participated where asked for a quiet room to remove as many outside distractions from the participants as possible. Participants were given a piece of paper to write any notes as the flight progressed and could use this as a reference when completing the questionnaire after the simulation. They were, however, not permitted to refer to the laptop screen or the Ipad with Westport's plate while completing the questionnaire. All observations could be referenced to the clock in the simulation aircraft; the clock was referred to in the preamble, the flight went from 8:38 on the clock to 8:48. The participants were informed that if they wanted to, they could refer to the clock when writing notes on their piece of paper. This gave each experiment run a level of uniformity and allowed ease of interpreting notes written by the participants. It also gave the participants a time reference not only for notes, but also when to conduct the review of the checklist (every two minutes).

The participants were asked if they were familiar with the simulator software and were given an overview of how the software worked, they were then provided with any information they would need for the simulation. The simulation was controlled by a wireless mouse located away to the side of the participants conducting the experiment, so as not to interfere with the process or create a distraction.

3.4 Design and Procedure

A simulation using Microsoft Flight Simulator was set up to be used to run the experiment. A Cessna 172 Skyhawk was the aircraft of choice for the simulation, due to the fact that most of the participants would have some familiarity with the aircraft. The participants were briefed on the aircraft and any questions any participant had were answered before commencement of the experiment, in order to avoid any confusion. The participants were split into the control and experimental groups by the flipping of a coin, to give groups even numbers. When one participant was put into either the control or experimental group the next would be put in the alternative group.

The experiment used was a pre-prepared and pre-set ten-minute flight between Hokitika and Westport, conducted at 3500 feet and at a heading of 000 (See Appendix C). The flight was conducted under visual flight rules (VFR), with the pilots required to keep a look out while the experiment was being carried out. They were shown how to execute a lookout, whether required to by a checklist or because they felt it was an appropriate action to undertake at that stage of the simulation. The flight had three pre-set failures set up to occur; the turn coordinator to fail at three minutes, the alternator to fail at five minutes and the second communication unit (Coms 2) to fail at eight minutes into the flight.

The effect of the turn coordinator failing is that the instrument would not display a turn when the aircraft rolls. The effect of the alternator failing is by way of a discharge shown on the ammeter in the cockpit and a “Volts” warning light illuminated in the cockpit. The final failure occurring in Coms 2 results in the second radio communication unit in the aircraft disappearing and becoming inactive.

Figure 3.4: Preset failures in the experiment

The indications of the failures are shown in Figure 3.4 above circled in red and highlighted by red arrows. The flight had a heading change occurring at four minutes into the flight and a change in altitude at seven minutes into the flight. The change in altitude is used to simulate a normal change in flight climbing from 3500 feet to 4500 feet; however, the change in heading, while also a normal change in flight, is also used to highlight the failed turn coordinator. The change in heading was 15 degrees, from 000 to 015, and took around 10 seconds. While this failure is only visible for a small amount of time, participants would be expected to check this instrument when conducting any turn in normal operations as it aids in rate of turn and whether the aircraft is in balance, as shown from the balance ball located directly under the turn coordinator.

3.5 Design of the Questionnaire

The questionnaire was designed using the above definitions of Situational Awareness; thus, it was designed to test the participant's first level of Situational Awareness (i.e., perception of elements in the environment) and the third level (i.e., projections of future status). Questions asked are intended to query what is happening around the pilot, and ask about items such as heading, altitude and communication settings. The questionnaire will also query participant's knowledge and understanding of expected outcomes and events; asking about the approaching airfield for landing and asking for their anticipation of such things as the runway the pilot expects to land on (See Appendix A).

The questionnaire then asks about the changing environment in the cockpit and about the pre-set failures of the experiment. This is designed to test the level of Situational Awareness the participants exhibit during the experiment and whether there is any difference in results between the control and experimental groups, potentially caused by the checklist. As stated, these areas will be analysing a participant's first and third level Situational Awareness. Testing the second level of SA could potentially be a topic for future research.

Due to the experiment being a simulation, the second level of Situational Awareness is not required by the participants; for example, participants do not need to comprehend the seriousness of the failures due to the lack of any real-world consequences. The experiment will, however, look into the participant's amount of level three SA; projecting future status of the flight was tested by the questionnaire administered after the experiment. For example, deciding what procedures will be required at the upcoming airfield.

For the purposes of this research and the interpretation of the data received, Situational Awareness was broken down into four areas: Active Situational Awareness or Active SA, Static Situational Awareness or Static SA, Continual Situational Awareness or Continual SA and Timing Situational Awareness or Timing SA. Static SA can be described as knowing the environment around a participant, or put simply how engaged a participant is. To determine the participant's level of static SA, questions have been asked in dichotomous form, to find out if a participant is as alert as they should be to things in the environment. Active SA, deals with the participant's ability to notice an unexpected change or a surprise: in the case of the experiment it is the participant's ability to notice a surprise in the form of the three pre-set failures. Continual SA combines whether the participants noticed a failure and how long they took to notice the failure. Timing SA only dealt with the participants who noticed the failures and measured how long it took to notice. The importance of measuring this factor alone is highlighted in a real-life example. If an alternator fault occurs in flight, noticing it quickly is important as this gives information to the pilot or crew to immediately conserve battery power for use in a more important stage of flight. If this fault is not noticed promptly there could be limited or insufficient battery power for a more critical stage of flight.

3.6 Questionnaire

The questionnaire created for the research had ten questions, designed to assess a participant's Situational Awareness in three stages (See Appendix A). The first stage being that of Static SA; this was testing things such as altitude of the flight, meteorological conditions and information about the destination aerodrome. The second stage of the questionnaire deals with the programmed failures within the flight. Referred to as Active SA, this stage examines not just whether the participant noticed the failure, but also whether it was acted upon. Timing SA was the last area tested, inquiring as to how long it took the participants to notice the failures. All these results were recorded and statistical analysis was then completed. Above the main questionnaire there are identifying questions; these give insight into the pilots that participated in the research. These questions were used to establish if a variable such as fatigue or experience had an effect on Situational Awareness in the experiment. The pilots are asked different questions, including information on what license they possess, whether they are instrument-rated, total number of flight hours, familiarity with the aircraft used in the simulation and amount of sleep in the pervious two nights combined.

The first seven questions were designed to test the participants' Situational Awareness in the cruise section of a flight. These questions can either be right or wrong, and are therefore scored either zero for an incorrect answer, or one for a correct answer. These scores were added together to get a score from zero to seven.

The last three questions asked if and when they noticed any one of the three preset failures. The dichotomous part of the questions, whether the participants noticed the failure or not, were added together giving a score out of three to measure the participants' level of Active SA. Continual SA was measured by allocating a score if a participant noticed a failure, and also took into account how much time it took to be noticed. Participants were scored a 0 if they missed a failure, 1 if a failure was perceived three minutes or more after the failure, 2 if a failure was perceived within two minutes and a 3 if a failure was perceived within the first minute. This scale was used for all three failures and an average was taken. For example, if a participant perceived all three failures within the first minute they occurred, they would score three points for all the questions and once averaged they would score a 3 in Continual SA

The timing component of the final three questions also asked the participants to put a specific time that they noticed the failure, if it was noticed. This was used to measure a participant's Timing SA. This section was ranked according to, and depending on the time the participants noticed the failure. The ranking system awarded a 1 to a participant who reports a failure within the minute it occurs, if a participant reports a failure between one minute and two minutes after the failure occurs a score of 2 is awarded. If a failure is reported two minutes and over after it occurs a score of 3 is awarded. Participants who reported multiple failures with different intervals, for example finding the amp meter discharge failure when it happens and the coms 2 failure a minute after it occurred, would be awarded a rank of 1.5, thus rewarding the participant for finding more than one failure. This ranking system was used, in order to show that a lower rank would signify less time taken to recognize a failure.

3.7 Checklist

In this experiment, the checklist was used to ensure that the pilot in the simulation has the aircraft configured properly for the cruise stage of flight and that certain critical instruments are not showing signs of an issue following the first point of the list referred to in section 2.5 above. The checklist used was designed to help the pilot obtain a higher level of Situational Awareness, increasing the second point of the above checklist. As designed, the checklist used will start at the first level, thereby helping the participant perceive status, attributes and dynamics of relevant elements in the environment. This includes other aircraft, terrain system status and warning lights (Endsley, 1999). This potential Situational Awareness is the premise of the experiment; i.e. does this checklist, or a checklist similar to it, give the pilot or pilots a higher level of Situational Awareness and therefore a potentially safer cockpit environment?

The experiment puts the participants in an automated flight situation, designed to be in the cruise where the pilots have set up the aircraft to cruise to its destination at a set altitude. Therefore, Situational Awareness of all the participants should be reduced and their attention could be directed to the wrong areas, especially given that the participants are taking a completely passive role in the simulation. Casner & Schooler, (2015) found that mind wandering for pilots increased when not interacting with the airplane or others, such as performing a radio call. They found that when someone has idle hands, mouths, and minds this was associated with mind wandering. They concluded that even while monitoring systems, there could be a safety issue for pilots. Endsley (1999) also found Situational Awareness was lower under fully automated conditions than under manual performance, linking a loss of attention which as stated can be a limiting factor to SA.

It must be noted however that one of the key advantages of automation and autopilot is the reduction of manual workload and fatigue (Wiener & Curry, 1980). This advantage could also prove to increase a pilot's Situational Awareness.

The checklist's intention is to remove this tendency of mind wandering from the participants and thereby increasing the workload of the experimental group. The premise behind the checklist is that it removes the passive role the participants are taking in the experiment, increasing their workload and making them more actively involved, thus more engaged and potentially heightening SA. The two-minute interval between checklists is used to attempt to achieve participant engagement throughout the entire experiment, bringing the participants back toward the ideal amount of workload to grant increased Situational Awareness.

The checklist created for the experiment had three items on it, and was designed to be completed in 10-15 seconds (See Appendix B). The first part of the checklist is a lookout, an important part of any aviation operation. When a flight is operated in VFR and a pilot is responsible for their own separation from other air traffic, the lookout is vital. The second part is checking the Directional Indicator (DI) to see that the aircraft is on the required heading and that the instrument is still aligned to the compass, and making any corrections required. The DI is aligned with the magnetic compass before takeoff and continuing to ensure that the instrument is still aligned with the compass is important for navigation, especially when using the auto pilot. If there is an issue with the DI coming out of alignment with the compass, this could highlight a larger issue to the pilot; potentially vacuum or suction systems failure, or failure with the compass itself. The last item on the checklist is the temperature and pressure of the aircraft's oil system (T's and P's). This is a common checklist item in aircraft including, and similar to, the Cessna 172. This is important to the running health of the engine and any issue with this system could lead to an emergency situation. A drop in pressure could indicate an oil pump issue or an oil leak, which could lead to an engine issue such as a failure and would require immediate action from the pilot. The temperature indication shows the pilot the temperature in the engine and oil system, and any issue being too high or low could indicate an issue with the engine, that again could require immediate action from the pilot.

All these areas are checked before and during the flight; pilots of these aircraft should be familiar with these checks and they should be able to be performed effectively in the appropriate amount of time. When operating in VFR, the pilot should always be looking out for other aircraft, landmarks for positioning for accurate navigation and reporting and ensuring the aircraft is clear of cloud and terrain. The checklist is a reminder for the pilots; the idea is to keep the pilots' focus on that aircraft's position and systems.

The checklist will be a paper checklist; a paper checklist consists of a list of items written on a paper card (Degani & Wiener, 1993; Neyman & Pearson, 1933). It will be written down for the participants to view and will not require them to remember. The viewing of this checklist will cue the participants to perform the checklist (See Appendix B). Again, the participants that were in the experiment group were told to complete the checklist every two minutes during the experiment. The control group was not given a checklist and their training and system knowledge was relied upon for their Situational Awareness.

As stated previously checklists can be a distraction; in order to avoid this the checklist consists of only three items, so as to keep this checklist from being a large or significant distraction for the pilot. To meet this requirement, the three items were designed to be completed in only 10-15 seconds. Future research could be focused on comparing how larger or smaller checklists could result in varying degrees of distraction in the pilot. It must be noted that this checklist is only for use in the cruise, and could be spread out over a longer period of time in an actual flight scenario. However, every two minutes in the test is an acceptable amount of time for a ten-minute flight time. If a real-world application was to go ahead, the length of time between checklists would need to be calculated so as to still be advantageous in increasing Situational Awareness, but not so that the checklist becomes tiresome and potentially disregarded.

As stated in the list above, checklists allow for mutual supervision among crew members (Asaf Degani, 1990).While the experiment is run with a single pilot, the inclusion of this checklist in a two-pilot system could be achieved with minimal complications and allow for this cross checking between the pilots of a flight crew.

It must not be implemented when other checklists are implemented in other stages of flight, however for extended periods when Situational Awareness could be lessened the implementation of such a checklist could prove useful. The checklist must be adjusted or altered however, to accommodate different aircraft conducting differing operations, as the checklist implemented for this experiment was designed for the Cessna 172 Skyhawk and other similar aircraft. It would need to be catered to aircraft as the operator or governing organization deems fit.

3.8 Variables

3.8.1 Experience

The participants are asked about their experience in terms of their level of license and number of flight hours. The experience is attempted to be measured to show if there is a causality between the experience of the pilot and Situational Awareness. Due to the research being conducted at flight schools, students and instructors were the expected participants, and therefore these participants were from pre-private pilot's license to C-Category Flight instructor and above. The levels of experience in the questionnaire were tailored for the participants that would be expected to be found. The participants were asked for their total flight hours: 0-50, 51-150, 151-300, 301-500, 501 hours and above were the options given as the pilots at the flight schools would be expected to be within these ranges. More experienced flight instructors or lifetime instructors would be possible outliers, with significantly more flight hours than the rest of the participants.

The participants were also asked if they had obtained an Instrument Rating and if they were familiar with the Cessna 172. Experience in these areas formed a variable that needed to be monitored. For example, a pilot who had done their instrument rating in a Cessna 172 could be very familiar with the aircraft and the readings from its instruments, meaning that any variation such as a pre-set failure might be more apparent compared to someone who does not have this level of experience.

With more experience, Situational Awareness would be expected to be increased. More advanced licenses, such as an Instrument Rating and Instructor ratings, would potentially lead to higher levels of Situational Awareness.

It must be noted that, with experience could come complacency and therefore Situational Awareness could be reduced.

Research from the Federal Aviation Administration (FAA) suggests that as pilots get past a point of experience the accident rates start to decrease, peaking around 250.5 hours for non-instrument rated general aviation pilots and 823.5 hours for instrument rated general aviation pilots (FAA, 2015). Due to the institutions that were used to find participants, most of the pilots found were under these hour amounts, meaning that the accident rates would be still increasing according to the above research.

3.8.2 Fatigue

As shown fatigue plays a large part of human factors and aviation safety systems. Aircrew, as well as ground crew, can all and do all suffer from fatigue. It was a factor in an estimated 4-7% of all civilian aviation mishaps (Caldwell, 2005). For this reason, fatigue was chosen to be one factor of the questions before the test was performed. It includes a simple question about the combined amount of sleep that the participant has had in the last two nights; as stated the amount of sleep is one of the major contributors to fatigue. The question did not ask for a specific number of hours, it asked for a total between two numbers of hours. For example, 10 to 13 hours of sleep in the last two nights. A two-night total was chosen to attempt to develop a more comprehensive analysis of the impacts of fatigue on Situational Awareness, in particular with fatigue playing such a large part in human factors and aviation safety in the current era. Adding a fatigue element to the research would not only be an attempt to reduce a confounding variable, but also give the ability to find the level, if any, of effect that fatigue would have on Situational Awareness.

It must be noted that the amount of sleep is not the only factor that contributes to fatigue, others include stress, health, travel, work demands and work environment (U.S. Department of Transportation, 2016). As stated however, sleep has been the most recognized factor; other factors and more could potentially be a topic of research in the future. The use of sleep as the variable to attempt to measure stress is the simplest measure for the participants. It allows for quick analysis of data, where using other factors would possibly require another questionnaire and could distract the participants.

3.9 Simulation compared to Real life

Nothing can take the place of a real-life event, especially in aviation where real life failure can have grave consequences. It must be noted that nothing will ever be able to replace the feeling of flying an aircraft and the level of awareness that is required, as is the case with the Spatial and

Temporal SA. While the simulation is done to the best of its ability with the limited resources available, it is anticipated that participants would still not be at the same level of alertness that they would be in a real-world scenario, due to the lack of safety consequences a simulation affords.

3.10 Ethics

Ethical considerations that needed to be considered were attempted to be minimized as much as possible. Keeping the participants anonymous was one main ethical consideration; the participants were assured that their identity would be kept anonymous in the research. No name was asked of the participants and any additional information, such as flight hours and license type, was taken as information about the participants and will only be printed in the results as an overall result instead of individual results, thus avoiding any possibility of recognition of a participant.

All information will be stored securely on the researcher's computer for a total of five years at least. It will not be able to be viewed by any other party without request.

Another ethical issue that had to be dealt with and minimized was any potential thought that participants from Massey University would be required to participate due to the research supervisor being a lecturer from Massey University. Potential participants could surmise that they would be required to participate in the research, or otherwise risk potential reprisal from the lecturer. For this reason, the lecturer in question was kept anonymous and the participants were not informed of the supervisory lecturer's involvement. This would also only be a potential issue when the students used were from, or had a current association with, Massey University.

The participants were found by visiting aero-clubs and flight schools around the North Island of New Zealand. Senior members of these clubs or schools were consulted and approved of the research before any testing was done, and all participants were volunteers. Any other participants were contacted through other aviation contacts. All these participants were also volunteers and there was no remuneration for participating.

One flight school asked if their students' results would be compared to any other school's results. They were reassured, and every subsequent school was assured, that this was not the intention of the research. Due to the anonymity of the participants this would be difficult to begin with and is in no way the intention of the research. Therefore, no school's participants were grouped together and no comparisons were made.

The research was deemed low risk by the ethics committee of Massey University, and on this proviso, it was approved. The ethical statement provided by Massey University was viewed by participants before the experiment took place.

3.11 Data Analysis

Two groups were specified for this experiment; the experimental group which is given a checklist to guard against the loss of SA, and the control group who does not receive the checklist. Therefore, the default hypothesis is directional, the experimental group is expected to have a better result and therefore higher levels of SA than the control group. As far as practicable this directional hypothesis will be used.

3.11.1 Fisher's Tests of Significance

Fisher's Tests of Significance was the method primarily used for the statistical testing of the experiment. It is used conventionally in psychological research, its advantages being the offering of practicality and flexibility in the analysis of data gathered. This approach is suitable to protect against unwarranted claims arising from the research data via testing against a null hypothesis of no effect in the population. The test of significance is set to the conventional level of significance of 5% or 0.05, one-tailed, against the control group. The only exception was with Static SA where the test was two-tailed as there was no expected directional effect.

For this research, the corresponding null hypotheses under the test were as follows:

- Non-directional $H_{0:}$ There is no effect in the population of reference, therefore the Control group and the Experimental group will show no meaningful differences in performance; any differences in performance found will be reasonably expected as random variation from a real difference of 'zero', shown as a non-significant result. If the research data returns a probability under the null hypothesis smaller than the level of significance 0.05, two-tailed, it shall be interpreted as potential evidence against H_0 and in favor of an effect.
- Directional $H_{0:}$ There is no positive effect in the population of reference, therefore the Experimental group will show no meaningful positive differences in performance; any positive differences in performance found will be reasonably expected as random variation from a real difference of 'zero' or, plausibly, as a negative difference, both shown as a non-significant result. If the research data returns a probability under the null hypothesis smaller than the level of significance 0.05, one-tailed, it shall be interpreted as potential evidence against H_0 and in favor of a positive effect.

The experiment had as main research hypothesis that the checklist applied to the participants in the experimental group would provide greater Situational Awareness than the control group that were not provided with a set checklist. All tests except for Static SA, were one-tailed (Experimental > Control), this was chosen because of its practicality in a real-world setting; the research is only interested in a finding where adding a checklist would be beneficial in Situational Awareness of what is current practice in the industry. If the research showed a significant finding that the checklist showed an increase in Situational Awareness, more research would be recommended as the null hypothesis would be rejected and an alternative hypothesis would need to be tested. However, finding any other result would require no action, as there is currently no checklist in use and subsequently no recommendations would be made, except potentially a recommendation that more research be done on the overall effect of checklists.

In a practical sense, an appropriate effect size for real world practicality must also be considered when selecting an effect size. In the case of this research a medium effect size was selected (Cohen's d = 0.5). This was deemed a practical effect size, so that any finding would be practically significant in terms of potentially being implemented in the real world. If a smaller effect size was found, it would be deemed not large enough to warrant an implementation of the checklist due to efficiency constraints and the costs of implementing such change.

Although controlling for power is desirable (Newman and Pearson, 1933; Cohen, 1988), the simple tests of significance by Fisher does not consider an alternative statistical hypothesis and, therefore, prevents the calculation of power a priori. A sensitiveness analysis was used instead (Perezgonzalez, 2017). A sensitiveness analysis is similar to power but fits better with the constraints of Fisher's tests, by ascertaining the sample required for obtaining a desired minimum effect size or larger as a statistically significant result, thus being equivalent to a priori power of 50% for such minimum effect size.

Due to above factors and a conventional significance level of 0.05, the number of participants deemed necessary for capturing a medium desired effect size of 0.5 (or larger), using one-tailed tests for independent groups, was forty-six. Therefore, forty-six participants were the minimum total number required for a one-tail test of significance, or twenty-three participants in each of the control and experimental groups.

3.11.2 Jeffreys's Bayes Factors

Another method used to evaluate the data was in the use of Bayes Factors. Bayes Factors were developed by Jeffreys's quantifying evidence in favor of a scientific theory. The centerpiece was a number, now called a Bayes factor, which is the ratio of two hypotheses when assuming a prior probability for each of one-half (Kass & Raftery, 1995). A Bayes Factor is a form of statistical inference in which one model is pitted against another, for example the null hypothesis (H_0) with an alternative (H_1) (Dienes, 2016). As stated Bayes factors gives a directional analysis of the data gathered. Bayes Factors calculate the ratio of model one over model two, (BF_{01}) or model two over model one (BF_{10}). This then provides support for either the null hypothesis or the alternative hypothesis.

While tests of significance are good tools to protect research from unwarranted inferential errors, for example from inferring a population effect when none exists, they have two main faults; one being they are unable to provide support for the null hypothesis under test in case of a nonsignificant result, and the other being that they are unable to give an estimate of credibility of an alternative hypothesis if the null hypothesis is to be rejected. The use of a Bayes Factor analysis will allow for the ability to go deeper into the data and to ascertain the support for either the null hypothesis or an alternative hypothesis. This approach was also used to give a broader look at the data collected, in an attempt to provide potentially more clarity. The asymmetric nature of the *p*-value is one of these reasons, due to this asymmetry the p-value cannot provide evidence for the null hypothesis (Dienes, 2016).

Jeffreys's default model for the null hypothesis concentrates the entire probability spectrum on 'zero' (the point-null hypothesis). It is, thus, a reasonable model when no differences in effect size exist.

The default model for the alternative hypothesis uses a Cauchy distribution centered on 'zero'. This distribution is akin to a *t*-distribution with one degree-of-freedom, thus resulting in a symmetric but rather flat distribution with heavy tails. By also being centered on 'zero', this alternative model does not require guessing an (unknown) effect size yet it is able to capture differences in effect sizes more readily than the null model.

When comparing data under both models, the null model will be more probable when the sample effect size accords to the null hypothesis, while the alternative model will be more probable as effect sizes deviate from those expected under the null model. This comparison (and associated likelihood) is what the Bayes Factor provides.

Therefore, the use of Bayesian testing could potentially give more evidence toward either hypothesis in a manner than Fisher's model cannot; this has a practical application as a checklist being added could potentially give a higher level of Situational Awareness. However, not having a checklist of this type is the current practice therefore nothing is lost if the checklist does not prove to improve SA, and in fact could show a reduction in Situational Awareness.

When using Bayes factors, interpretation of a study only depends on the data at hand, the priors and the specific model of data-generating process (Schönbrodt, Wagenmakers, Zehetleitner, & Perugini, 2017). Therefore, a prior must be used when using Bayes Factors to interpret the data sets; for the purpose of this project a default Cauchy scale of 0.707 was used due to the lack of prior information.

Chapter 4

Results

With Situational Awareness being such a vital part of aviation safety, an attempt to increase this is the ultimate goal; the results below show how a checklist affected SA of the participants involved, using both Fisher's Test of significance and Jeffreys's Bayes Factors. The test of significance will provide information regarding whether to accept or reject the H_0 underlying each of the tests. The Bayes Factors analysis, carried out subsequently, will serve to inform whether the results obtained supports the null or the alternative hypotheses, and the degree of confidence for such support. The main results will be broken down into Static Situational Awareness, Active Situational Awareness, Continual Situational Awareness and Timing Situational Awareness.

4.1 Static SA

Table 4.1 *Static SA Statistics*

Group	N	M	SD	CI
Control	23	4.44	1.31	[3.90,4.99]
Experimental	23	4.17	1.34	[3.62,4.72]

From Table 4.1 it can be seen that the means of both the control (non-checklist) and the experimental (checklist) groups exhibit very little variation. The experimental group show a slightly lower mean, also reflected in the somewhat off-centred confidence interval (CI 95% [3.62,4.72] compared to the control group (CI 95% [3.90 , 4.99]) . However, the overall difference is of one quarter of a score on the scale, a difference too small to be of practical importance.

Given that the scale for Static SA runs from a minimum of '0' (if no item was remembered correctly) to a maximum of '7' (if all items were remembered correctly). Table 4.1 shows that both the control and experimental groups performed well, remembering, on average, some four items out of seven.

4.1.1 Static SA Test of Significance

Table 4.1.1 *Static SA Significance Test*

Cohen's d	**CI**	**t**	**df**	**p**
0.20	[-0.53 , 1.00]	0.67	44	0.51

Static SA comprises items of awareness that the pilot should be able to remember but are not subjected to continual monitoring. Therefore, they were not expected to be directionally affected by the experimental intervention. The results shown in Table 4.1.1 are therefore, non-directional two tailed statistics.

From table 4.1.1 it can be seen that the standardized mean difference between groups is a Cohen's d = 0.20, which is not rare in psychology and which could be considered small but not negligible. However, as described earlier, such effect only represents a one-quarter of a score on the scale used, and seems trivial in context. The confidence interval for such a standardized difference, conditional on the sample size, runs between -0.53 and 1.00, thus crosses ‘0’, signaling a non-significant result. Indeed, a proper two-tailed t-test for independent samples returns such non-significant result ($p = 0.51$).

4.1.2 Bayes Factor Analysis

Table 4.1.2 *Static SA Bayes Factors*

BF_{01}=2.85	Credible Intervals Control [3.87 , 5.00] Experimental [3.60 , 4.75]

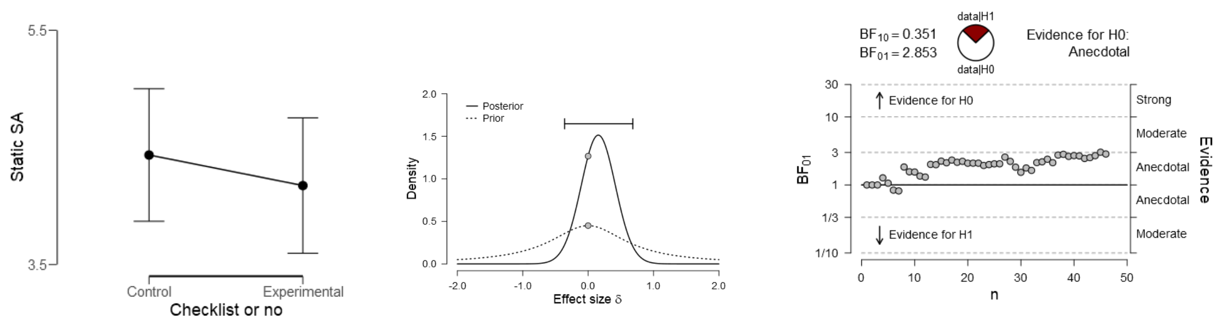


Table 4.1.2 shows the results for the Bayes Factors analysis. We can see that the credible intervals for each group follow the same pattern described above, with the groups being rather similar in location and spread.

The Bayes factors analysis shows that the null model H_0 is almost three times more likely than the alternative model (BF_{01}= 2.85). This suggests that there is some anecdotal support in favor of the null hypothesis that there is no difference in Static SA between the control and experimental groups.

4.2 Active SA

Table 4.2 *Active SA Statistics*

Group	N	M	SD	CI
Control	23	1.22	0.60	[0.98 , 1.47]
Experimental	23	0.70	0.70	[0.41 , 0.99]

From Table 4.2 it can be seen that the means of both control (non-checklist) and experimental (checklist) are rather different. The experimental group show a lower mean, also reflected in the off-centred confidence interval (CI 95% [0.41, 0.99] compared to the control group (CI 95% [0.98 , 1.47]) . The difference is almost half a score on the scale and therefore an effect of potential importance.

Given that the scale for Active SA was run from a minimum of ‘0’ (if no failures were noticed) to a maximum of ‘3’ (if all failures were noticed), Table 4.2 shows that both the control and experimental groups had underwhelming results, each perceiving just about one out of three items of Active SA. The control group performed better (M= 1.22) than the experimental group (M= 0.70), against initial expectations.

4.2.1 Active SA Significance Testing

Table 4.2.1 *Active SA Significance Test*

Cohen's d	CI	t	df	p
0.80	[-∞ , 0.10]	2.71	44	0.99

Active SA comprises items of awareness that the pilot should monitor continually as the flight progresses, and they were expected to be positively affected by the experimental intervention. The results shown in Table 4.2.1 are, therefore, directional or one-tailed.

From table 4.2.1 it can be seen that the standardized mean difference between groups is a Cohen's d = 0.80 showing that a medium effect has been potentially found. As described above, such effect represents almost half of a score on the scale used. The confidence interval for such a standardized difference, conditional on the sample size, runs between -∞ and 0.10 therefore crossing '0' and signaling a non-significant result. Indeed, a proper one-tailed t-test for independent samples also returns such non-significant result (p = 0.99).

4.2.2 Bayes Factors Active SA

Table 4.2.2 *Active SA Bayes Factors*

BF_{01}= 10.96	Credible Interval Control [0.96 , 1.47] Experimental [0.39 , 1.00]

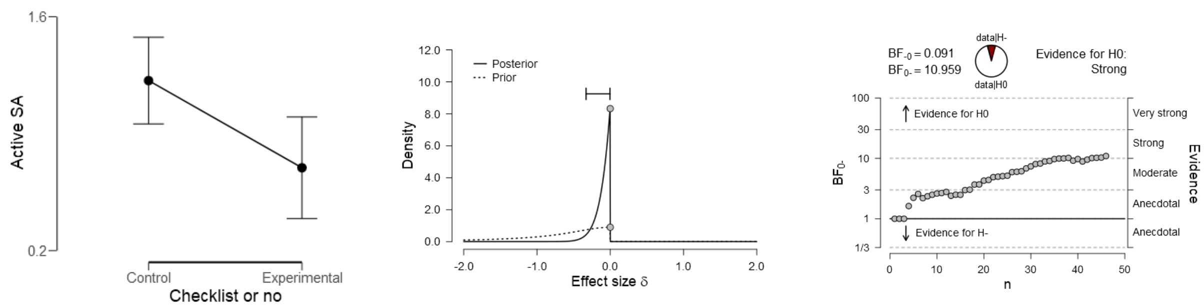


Table 4.2.2 shows the results for the Bayes Factors analysis. We can see that the credible intervals for each group follow the same pattern described above, with the groups differing sensibly in location and spread. It is visually evident that the experimental group performed worse than the control group, against expectation.

The one-tailed Bayes factors analysis shows that the null model H_0 is almost eleven times more likely than the alternative model (BF_{01}= 10.96). This Bayes Factors suggest moderate support in favor of the null hypothesis and, therefore, against the initial research hypothesis. In summary the experimental group did not perform better than the control group in Active SA.

4.2.3 Active SA Two Tailed Analysis

Table 4.2.3 *Active SA Two Tailed Significance Test*

Cohen's d	CI	t	df	p
0.65	[0.19 , 1.40]	2.71	44	0.01

Before moving on, it seems relevant to explore further the mismatch between the initial expectations of improvement and the obtained results, especially in view of the latter seemingly going in the opposite direction. Therefore, the significance test was re-run for Active SA, this time using a two-tailed test.

Table 4.2.3 shows a significant result in favor of the null hypothesis. Confidence intervals runs between 0.19 and 1.40 and a p value of 0.01. This evidence suggests that the checklist could have been a hindrance to Active SA rather than simply been not helpful.

4.3 Continual SA

Table 4.3 *Continual SA Statistics*

Group	**N**	**M**	**SD**	**CI**
Control	23	0.96	0.59	[0.72 , 1.20]
Experimental	23	0.67	0.67	[0.39 , 0.95]

From Table 4.3 it can be seen that the means of both control (non-checklist) and experimental (checklist) groups are rather similar. The experimental group show a lower mean, also reflected in the somewhat off-centred confidence interval (CI 95% [0.39 , 0.95]) compared to the control group (CI 95% [0.72 , 1.20]) . The difference between these CI does not show a large difference in the groups.

Given the scale for Continual SA ran from a minimum of '0' (if no failures were noted and therefore no time was given) to a maximum of '3' (if all failures were noticed in a timely manner); Table 4.3 shows that both the control and experimental groups had underwhelming results, on average, 0.67 (experimental) and 0.96 (control) out of a possible of three. No participant managed to achieve a maximum score of three.

4.3.1 Continual SA Significance Testing

Table 4.3.1 *Continual SA Significance Test*

Cohen's d	CI*	t	df	p
0.46	[-∞ , 0.60]	1.55	44	0.94

Continual SA comprises items of awareness of Active SA expected to be monitored continually, the measure also added a timing component. This measure was supposed to be affected positively by the experimental intervention. The results shown in table 4.3.1 are directional or one-tailed.

From Table 4.3.1 it can be seen that the standardized mean difference between groups is a Cohen's d = 0.46. Showing a small, non-negligible, effect. The confidence intervals for such a standardized difference, conditional on the sample size, runs between -∞ and 0.60, thus crossing '0' and signaling a non-significant result. A proper one tailed t-test for independent samples also returns a non-significant result ($p = 0.94$). Similarly to what happened with Active SA, from the effect size and non-significant result it can be seen that use of a checklist did not have the expected positive effect on Continual SA either.

4.3.2 Bayes Factors Continual SA

Table 4.3.2 *Continual SA Bayes Factors*

BF_{01} = 7.71	Credible Interval
	Control [0.70 , 1.21]
	Experimental [0.38 , 0.96]

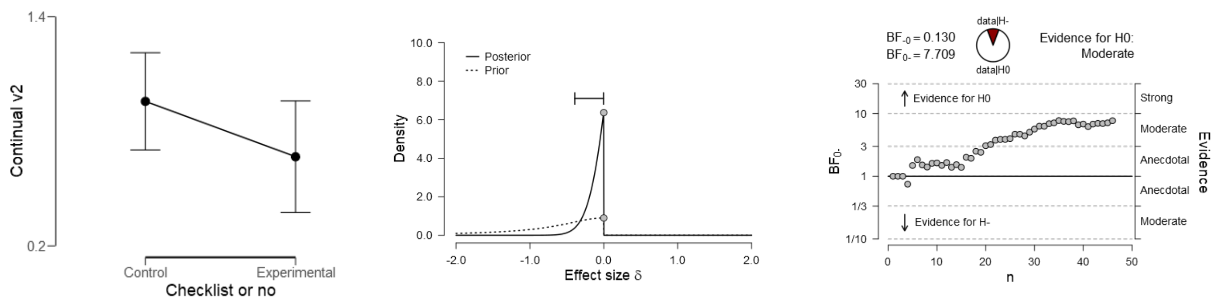


Table 4.3.2 shows the results for the Bayes Factors analysis. We can see that the credible intervals follow the same pattern described above, with the groups differing slightly in location and spread.

The Bayes factors analysis shows that the null model H_0 is almost eight times more likely than the alternative model (BF_{01}= 7.71), suggesting that there is moderate support in favor of the null hypothesis and therefore, that the experimental group did not perform better than the control group.

4.4 Timing SA

Table 4.4 *Timing SA Statistics*

Group	N	M	SD	CI*
Control	20	1.58	0.85	[1.21 , 1.95]
Experimental	13	1.12	0.30	[0.96 , 1.28]

Timing SA comprises the time interval it took pilots to perceive whatever failures in the cockpit were perceived. The scale is in inverse categorical minutes, running from ‘1’, if it took three minutes or longer to capture a failure or no time was provided, to ‘3’, if the failure was captured within a minute of it occurring.

From Table 4.4 it can be seen that the control (non-checklist) group had a poorer score than the experimental (checklist) group. The experimental group showed a lower mean, which in this instance is a more beneficial score. This difference is reflected in the off-centered confidence interval (CI 95% [0.96 , 1.28] of the experimental group compared to the control group (CI 95% [1.21 , 1.95]) . The difference between these groups is pronounced (i.e., half a score on the scale, equivalent to 30 seconds) and suggests an important effect size.

4.4.1 Timing SA Significance Testing

Table 4.4.1 *Timing SA Significance Test*

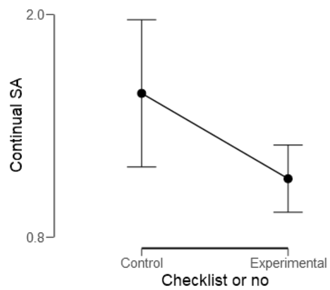
Cohen's d	CI*	t	Df	p
0.67	[0.07 , ∞]	2.08	31	0.04

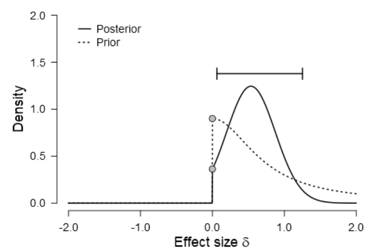
From table 4.4.1 it can be seen that the standardized mean difference between groups is a Cohen's d = 0.67, meaning a medium to large effect. The one-tailed confidence interval for such a standardized difference, conditional on the sample size, runs between 0.07 and ∞, thus above '0' and signalling a statistically significant result. A proper one tailed t-test for independent samples also returns a significant result (p = 0.04). The null hypothesis can be rejected.

4.4.2 Bayes Factors Timing SA

Table 4.4.2 *Timing SA Bayes Factors*

BF_{10}=2.35	Credible Intervals Control [1.18, 1.97] Experimental [0.93 , 1.27]





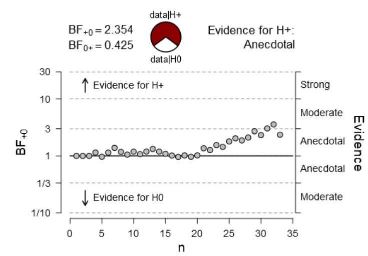


Table 4.4.2 shows the results for the Bayes Factor analysis. We can see that the credible intervals follow the same pattern described above, with the groups differing in location and spread.

The Bayes factors analysis shows that the alternative model H_1 is just over two times more likely than the null model (BF_{10}= 2.35). This suggests moderate support in favor of the alternative hypothesis, therefore that the checklist may have some positive effect on Situation Awareness (in this case, in speed at which a failure is perceived).

4.5 Variables

Table 4.5 – *Distribution of Participants throughout the Variables*

	Control	Experimental
Have Flown a 172		
Yes	**7**	**5**
No	**16**	**18**
Instrument Rating		
Yes	**11**	**16**
No	**12**	**7**
Level of License		
C-CAT	**7**	**7**
CPL	**6**	**7**
PPL	**7**	**6**
PRE PPL	**3**	**3**
Flight Hours		
0-50	**2**	**3**
51-150	**5**	**2**
151-300	**6**	**6**
301-500	**5**	**8**
501+	**5**	**4**
Hours of Sleep 2 Nights		
6-10	**3**	**3**
11-15	**16**	**12**
16+	**4**	**8**

As can be seen in Table 4.5 the distributions are similar and there is random variation between the control and experimental groups. While the distribution is not even, the variation is to be expected and does not seem to have altered the results.

Chapter 5

5.1 Discussion

The checklist was not intended to have an effect on the pilot's Static SA; Table 4.2 shows a difference between the means that could be explained as random variation around a real difference of zero in the population. However, Cohen's d value of 0.2 gives the suggestion of a small effect size, with the sample size consisting of 46 participants. Although random variation is the most likely cause, the outcome remains the same even if the result is due to real world variables. This is because the costs of a change in procedure/policy can be huge, and a significant result is necessary to make this economical. The results found above regarding Static SA, signified by the p value of 0.51, indicate that a recommendation for policy change cannot be made.

When the results for the control and experimental groups were compared, there was a marked reduction in Active SA. This suggests there could be a potentially negative impact on Active SA caused by the checklists. The results from Table 4.3 exhibit a non-significant result, with a p value of 0.98, and the higher confidence interval being just above 0 at 0.03 supports this conclusion. Bayes Factor analysis supported this also, suggesting that there was anecdotal evidence for H_0. This contrasted with the hypothesis, as the checklist was expected to have the effect of increasing workload towards the optimum level and therefore increasing SA.

The overlap in the credible intervals of the means was small, suggesting that there could be a greater effect found. Bayes Factors, however, give evidence that the null hypothesis is almost eleven times more likely than the alternative. This could suggest that with Active SA, the checklist had no effect despite what was expected.

This is further supported by the two-tailed analysis conducted and the significant result found. While the research was not designed to conduct two-tailed testing, it does provide insight into the results gathered. This indicates that the checklist was potentially having a detrimental impact.

Another non-significant result was discovered in the analysis of the checklist's effect on Continual SA, as seen in Figure 4.3. The mean of the control group was superior to the experimental group, again suggesting that either there was no difference between the groups or that the checklist was the cause of a lowering of Situational Awareness. Bayes Factor analysis supports this conclusion that the control group exhibited superior Situational Awareness, with the results suggesting that the null hypothesis is almost eight times more likely. This further supports the conclusion that the checklist had little to no effect on Situational Awareness, rather than the expected beneficial increase.

Timing SA displayed a significant result, thus rejecting the null hypothesis in this case. It must be noted that using Fisher's testing does not support the alternative hypothesis, as that is not known. Bayes Factors gives some direction to the results, as they suggest that the research hypothesis is almost three times more likely than the null hypothesis. While this is moderate evidence for H_1, there is the potential that with a larger sample size a more pronounced positive effect would be discovered in Timing SA, given the magnitude of the result found in earlier tests. In this case the use of a checklist gave a better response time at noticing a failure. This faster response time could lead to the minimizing of an issue discovered by a flight crew.

Given these results, the overall conclusion has to be that there wasn't enough of an increase in Situational Awareness to warrant the implementation of the checklists. In the area of Active SA and Continual SA the checklist exhibited a negative effect on SA, both with moderate to strong evidence supporting the null hypothesis. The use of two models aided with flexibility when evaluating the data, as Fishers approach provided insight into the null hypothesis, "is there potential for an increase in SA", and the Bayesian approach proved "which one of these hypotheses or approaches is superior".

The results gathered above point to the conclusion that the checklist should not be implemented. This is due to the null hypothesis as suggested by Fisher's test, although non-significantly, backed up by the evidence from the Bayesian testing supporting the null over the alternative hypothesis. Timing SA exhibited moderate evidence for the alternative hypothesis, suggesting that the checklist did have the desired effect. However this increase in SA, while valuable, would not warrant the suggested inclusion of a checklist due to the counterbalancing results gathered in the other areas of SA.

The reason for this unexpected set of results could have been found in the other variables gathered, however they do not point to a reason. These other factors all exhibited a relatively even distribution between the participants, and any small variation was within the expected margin. Therefore, a conclusion cannot be made that these factors were responsible for the negative results.

A potential reason for the less than desired outcome could be that the checklist acted as a distraction, rather than an aid. This is the complete opposite of what a checklist is implemented for. The question however is why the checklist proved to be a distraction; this could come down to the pilots' training and how the implementation of a new technique could be a potential distraction. When a pilot is training and conducting flights, all safety procedures, including checklists are rehearsed many times over until they become instinctive and second nature. This can subsequently ascribe a degree of risk in the implementation of a new technique which falls outside the above training regimen. While the checklist was designed to be as familiar as possible to minimize time expended, their inexperience with the checklist could have proved distracting. The participants could have then assigned a relatively greater degree of attention to the new checklist, at the expense of their usual tasks, leading to a misplacement of attention and therefore a drop in SA.

Due to the nature of the aviation setting, the impact of the research on cost, time, and safety creates a limit on the ability to carry out this type of research effectively. To this end aviation is a relatively reactive safety environment, making the implementation/testing of new procedures especially challenging. It is suggested that for Situational Awareness the checklist could have been a distraction for the participants and as previously stated, this is the opposite of its intended function. To summarise, the recommendation can be made that if a future experiment were to be conducted, the intervals between checklist completions can be extended, as well as implementation of a longer flight time. It is entirely possible that completing a checklist four times in the space of ten minutes may have caused a distraction instead of the heightened SA it was designed to promote.

In a practical sense, and taking into account the results gathered from this experiment, the effect size of the increase in Timing SA is too small to warrant a change in the real world. The results do however point to the fact that future expanded experimentation could prove a positive outcome in Continual Situational Awareness. Given the resources that were available, the research and data gathered provides a good starting point for future experimentation to springboard from.

5.2 Limitations

Some limitations of the research have been alluded to previously, and as stated a more comprehensive simulator would have been beneficial. However the participants who were being sought could not have been captured without the use of a mobile simulator. If this research was to be repeated a more comprehensive simulator could provide more precise results, but for the most accurate results an experiment run in the real world would be necessary. This, however, is a very unrealistic scenario. The experience level of the participants was another potential limitation during the experimentation process. The participants gathered where chosen due to their relative ease of selection. The use of more experienced pilots, for example active airline pilots, could also prove beneficial, despite the challenge of this being a more difficult group to capture logistically. These pilots are accustomed to operating in mainly automated flight conditions, where Situational Awareness can be adversely affected and a checklist such as the one implemented for this research could prove beneficial to safety.

5.3 Recommendations

Use of a better simulator could prove to be the best way forward for any further research. Added to this is the fact that pilots as a group are hard to find in numbers that would satisfy traditional power analyses, no matter the method used. While more participants would potentially prove valuable, the expense and time it would take to gather participants could be prohibitive, especially if a more complex and real-world type of simulator were used. One must also take into account that these real-world types of simulators are not generally mobile.

It can therefore be surmised that future research would ideally be suited to a government agency such as the CAA, who have the ability to provide a greater degree of scope and funding for the experimentation process, or an airline that is able to provide their own simulator, such as Air New Zealand. These organisations have ready access to pilots who require simulators to complete competency checks and training, with the potential to provide the optimal experimental conditions. While time and money limitations shaped how the experiment was set up and executed, the experiment was set out in the best way possible in order to thoroughly test the hypothesis; any improvements in capturing information may include the potential use of an approved CAA synthetic flight trainer (SFT). Again, for this particular experiment and research this would have proved problematic, as an SFT does not provide the mobility that the selected set-up did. An SFT, however, is more similarly related to a real cockpit and would give a much more real-world experience without the considerable expense, unrealistic time frame, and safety concerns of using real aircraft in flight.

No matter the outcomes in this instance, there is still no replacement for the actual cockpit, where the environment itself is a distraction and can potentially reduce a pilot or flight crew's Situational Awareness. Completing research in this area, while not only impractical, is almost impossible. This is one reason why safety systems in aviation, unless derived from common sense, tend to be developed in reaction to an event rather than proactively. \

5.4 Conclusions

The results proved to be non-significant, pointing to either a hindering of SA or a null effect. There is only a small increase in SA in a limited capacity, implying that the application of the checklists could prove detrimental in a real-world scenario. Implementation of the checklists with proper timing and more realistic simulation could prove crucial to future experimentation.

Situational Awareness is a key component of aviation safety, especially considering the number of accidents and incidents that can be attributed to human error. SA plays a vital role in this and therefore research into this area is valuable despite the marginal result, as the potential beneficial impact of even a small increase in SA warrants further research. Future research could be aided by a larger pool of participants, in combination with a more comprehensive synthetic flight simulator. Bayes Factors would be recommended due to the ability to give a decisive direction to future research, especially given the two main limitations of this research; the lack of potential participants and the equipment required. The Bayesian method proved valuable in this research, giving both direction and some insight to non-significant results.

While overall the research did not conclusively find an effect that would warrant a recommendation for a change in aviation practice, it does warrant continued research, especially as there is a positive effect found in one category (Timed SA). The other potentially interesting discovery of this research is the reduction in SA found in multiple categories. This implies that in certain cases a checklist can in fact be detrimental rather than beneficial to a pilot's Situational Awareness, and the ramifications of this result could prove to be a useful avenue for future research.

References

AIRBUS. (1995). *Coping with Long-Range Flying.* Toulouse: AIRBUS.

AirBus. (2007). *Flight Operationss Briefing Notes Human Performance Enchancing Situational Awareness.* Bellonte: AirBus.

Asaf Degani, E. L. (1990). *Human Factors of Flight-Deck Checklists: The Normal Checklist.* Washington DC: NASA.

Baddeley, A. D. (1983). Working Memory. *Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences* , 311-324.

Boeing. (2016). *Statistical Summary of Commercial Jet Airplane Accidents.* Seatle: Boeing Commercial Airplanes.

Byrne, M. D., Kirlik, A., Allard, T., Foyle, D. C., Hooey, B. L., Gluck, K. A., et al. (2008). Issues and Challenges in Human Performance Modeling in Aviation: Goals, Advances, and Gaps. *Proceedings of the Human Factors and Ergonomics Society Annual Meeting* , 926-929.

CAA. (2016, February 1). PArt 125 CAA Consolidation . Civil Aviation Authority of New Zealand.

Caldwell, J. A. (2005). Fatigue in Aviation. *Travel Medicine and Infectious Disease* , 85-96.

Casner, S. M., & Schooler, J. W. (2015). Wigilance impossible: Diligence, distraction, and daydreaming all lead to failures in a apractical monitoring task. *Consciousness and Cognition* , 33-41.

Chialastri, A. (2012). Automation in Aviation. In F. Kongoli, *Automation* (pp. 79-102). Croatia: In Tech.

Cohen, J. (1988). *Statistical Power Analysis for Behavioural Sciences (2nd ed).* New York, NY: Psychology Press.

Degani, A., & Wiener, E. L. (1993). Cockput Checklists: Concepts, Design, and use. *Human Factors: Journal of the Human Factors and Ergonomics Society; Vol 35 no. 2* , 28-43.

Degani, A., & Wiener, E. L. (1993). Cockput Checklists: Concepts, Design, and use. *Human Factors: Journal of the Human Factors and Ergonomics Society; Vol 35 no. 2* , 28-43.

Degani, A., & Wiener, E. L. (1990). *Human Factors of Flight-Deck Checklists: The Normal Checklist.* Washington DC: NASA.

Department of The Airforce. (2014, October 17). G AWARENESS FOR AIRCREW. *AirForce Pamphlet 11-419* .

DiDomenico, A., & Nussbaum, M. A. (2008). Interactive effects of physical and mental workload on subjective workload assessment. *International Journal of Industrial Ergonomics* (38), 977-983.

Dienes, Z. (2016). How Bayes factors change scientific practice. *Journal of Mathmatical Psychology* , 78-89.

Endsley. (1999). Situation Awareness in Aviation Systems. In D. J. Garland, J. A. Wise, & V. D. Hopkin, *Handbook of Aviation Human Factors* (pp. 257-276). Mahwah: Lawrence Erlbaum Associates.

Endsley, M. R. (1996). Automation and Situation Awareness. *Automation and Human Performance: theory and applications* , 163-181.

Endsley, M. R. (2000). Theroetical Underpinnings if Situational Awareness: A Critical Review. In M. R. Endsley, & D. J. Garland, *Situational Awareness Analysis and Measurement* (pp. 3-27). Boca Raton: CRC Press.

FAA. (1995). *Human Performance COnsiderations in the Use and Design of Aircraft Checklists.* Washington DC: U.S Department of Transportaiton.

FAA. (2015). *Predicting Accident Rates From General Aviation Pilot Total Flight Hours.* Washington DC: FAA.

Ji, Q., Lan, P., & Looney, C. (2006). A Probabilistic Framework for Modeling and Real-Time monitoring Human Fatigue. *IEEE Transactions on Systems, Man, and Cybernetics- Part A: Systems and Humans , 36* (5), 862-875.

Kass, R. E., & Raftery, A. E. (1995). Bayes Factors. *Journal of the American Statistical Association* , 773-795.

Mancas, M. (2016). What is Attention? In M. Mancas, V. P. Ferrera, N. Riche, & J. G. Taylor, *From Human Attention to Computational Attention A Multidisciplinary Approach* (pp. 9-20). New York: Springer Science+BUsiness Media.

Manning, S. D., Rash, C. E., LeDue, P. A., Noback, R. K., & McKeon, J. (2004). *The Role of Human Causal Factors in U.S. Army Unmanned Aerial Vehicle Accidents.* U.S. Army Aeromedical Research Laboratory, Aircrew Health and Performance Division. Fort Rucker: U.S. Army Aeromedical Research Laboratory.

Neyman, J., & Pearson, E. (1933). On the Problem of the Most Efficient Tests of Statistical Hypotheses. *Philosophical Transactions of the Royal Society Of London, Series A, Containing Papers of a Mathematical or Physical Charater* (231), 289-337.

NTSB. (2011, February 1). Lessons from Icing Accidents and Incidents. United States of America: National Transportation Safety Board.

Perezgonzalez, J. D. (2017, February 14). Sensitiveness for the Behavioral Sciences. https://osf.io/y969t/

Rankin, A., Woltjer, R., Field, J., & Woods, D. (2013). “Staying ahead of the aircraft ” and Managing Surprise in Modern Airliners. *5th Resilience Engineering Symposium: Managaging trade-offs.* Soesterberg.

Schönbrodt, F. D., Wagenmakers, E.-J., Zehetleitner, M., & Perugini, M. (2017). Sequential Hypothesis Testing With Bayes Factors: Efficiently Testing Mean Differences. *Psychological Methods* , 322-339.

Skybrary. (2016, May 25). *Level Of Arousal*. Retrieved from Skybrary: https://www.skybrary.aero/index.php/Level_of_Arousal

Stanton, N. A., Chambers, P. R., & Piggott, J. (2001). Situational awareness and safety. *Safety Science* , 189-204.

U.S. Department of Transportation. (2016, December 2). Maintainer Fatigue Risk Managment. *Advisory Circular* . Washington DC, United States of America: FAA.

USA Today. (2014, Aug 11). *Ask the Captain: How often is autopilot engaged?* Retrieved from USA Today: https://www.usatoday.com/story/travel/columnist/cox/2014/08/11/autopilot-control-takeoff-cruising-landing/13921511/

Veltman, J. A., & Gaillard, A. W. (1996). Physiological indices of workload in a simulated flight task. *Biological Psychology , 42* (3), 323-342.

Wickens, C. D. (2008). Situation Awareness: Review of Mica Endsley's 1995 Articles on Situation Awareness Theory and Measurement. *Human Factors: The Journal of the Human Factors and Ergonomics Society , 50* (3), 397-403.

Wiener, E. L., & Curry, R. E. (1980). Flight-deck automation: promises and problems. *Ergonomics* , 995-1011.

Appendices

Appendix A

Questionnaire

"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 (Research Ethics), email humanethics@massey.ac.nz. "

Research Undertaken by Massey University Masters Student Nicholas Vincent

Any recorded information is confidential and will not be revealed to any other party, this research and all it entails is completely voluntary and any participant my leave at any time during the experiment. This experiment requires 10-15 minutes of time and is done in two parts. The first part is a 10-minute simulated flight between Hokitika and Westport, part two is a short questionnaire. Please ask if there is anything you are unsure about before and after the experiment.

Please circle only one response to these questions

Current license

Pre PPL student	PPL	CPL	C-Cat and Above

Instrument rated

Yes	No

Total number of flight hours

0-50	51-150	151-300	301-500	501 and above

Hours of Sleep in the last two nights

None	1-5	6-10	11-15	16 and above

What follows is a flight between Hokitika and Westport in VFR conditions and the wind conditions at Westport are 000 degrees magnetic at 15 knots. The aircraft is a Cessna 172 SkyHawk, if you are not familiar with the aircraft please inform the researcher. The flight is the going to be ten minutes long, all that needs to be done by the participant is to monitor the flight as the aircraft approaches Westport. The aircraft will be controlled by the auto pilot, and the researcher. Any changes to the aircraft will be done by the researcher, and any observations or changes you may note on a piece of paper provided.

Question 1

What is the active runway at Westport?

Question 2

What was the aircrafts transponder code?

Question 3

What altitude did the aircraft start the flight at?

Question 4

What was the elevation of the Westport aerodrome?

Question 5

What was the current cloud cover? (in oktas)

Question 6

Was there any other air traffic located?

Question 7

Where all the instruments working properly?

Question 8

What and when was the first failure?

Question 9

What and when was the second failure?

Question 10

What and when was the third failure?

Appendix B

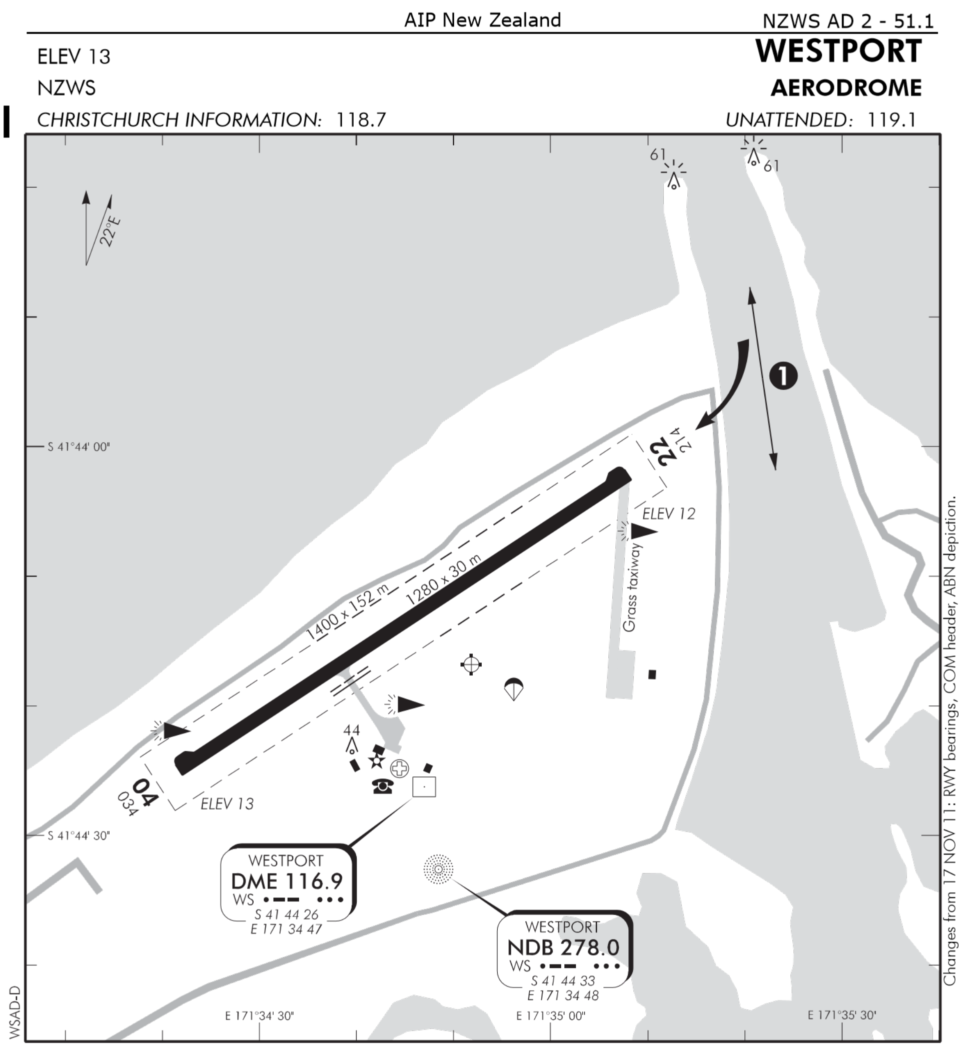
Checklist

L – Lookout

DI – Check the compass and Directional Indicator are aligned

Ts & Ps – Check the Temperature and Pressure gauges are In the green range

Appendix C



❶ **CAUTION:** Shipping obstruction:

Take-off and approach fans to the north-east may be obstructed by passing shipping with mast heights up to 65 ft above aerodrome elevation. Take-off RWY 04 and landing RWY 22 should be delayed until shipping is clear.

2. Circuit: RWY 04 — Left hand
   RWY 22 — Right hand
3. Grass areas parallel to RWY 04/22 closed to all movements.
4. Microlight aircraft operations take place from eastern grass taxiway.
5. Model Aircraft Club operates at southern end of grass taxiway on Saturdays, Sundays and public holidays between 0800 and 1700 local time.
6. **CAUTION:** Bird hazard. Plovers and seagulls continually present.

S414417 E1713451 WESTPORT

Effective: 14 SEP 17

E Civil Aviation Authority

AERODROME

Certificated Aerodrome 1 NM NW of Westport

WESTPORT

NZWS

OPERATIONAL DATA

RWY

RWY	SFC	Strength	Gp	Slope	ASDA	Take-off distance			LDG DIST
						1:20	1:30	1:62.5	
04 22	B	LCN 35 H=30	8	Nil	1280			1280	1280

MINIMA

IFR Take-off		
RWY	Day	Night
04	300–1500	500–3000
22	400–1500	500–3000

D

LIGHTING

PAL 119.1:	Standard operation — transmit 5 pulses of 0.3 SEC duration within 3 SEC activates lights for 30 min. WDI in front of the terminal will flash for the last 10 min prior to shutting off. Repeat transmission resets lights for a further 30 min.
Runway:	04/22 LIL RWY, APAPI 3.0 /TCH 50
Aerodrome:	ABN FLG W 3.0 SEC, WDI
Turning Bay:	Edge
Taxiway:	Edge Apron: Edge
Standby power available	

FACILITIES

Fuel: Avgas 100 and Jet A1, BP swipecard required. Fuel supply located near terminal building.

SUPPLEMENTARY

Operator: Westport Airport Authority, C/– Buller District Council, PO Box 21, Westport.
Tel (03) 788 9111 Fax (03) 788 8041

Available for general use without the permission of the operator.

Landing fees. An honesty box system is in place for aircraft up to 2000 kg. Additional costs for invoiced landing costs.

Operators of aircraft with MCTOW above 2000 kg please enter landing details on envelopes provided and place in fee box located at the end of the terminal.