The Transformation of Risk Perception & Risk Tolerance of Airline Pilots as they progress through their career

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Abstract

Risk perception and risk tolerance are key elements of decision-making and flight safety. During flight operations, an accident may occur if a pilot underestimates risk level or overestimates their capacity (risk tolerance). Despite the numerous research studies conducted previously on risk perception and risk tolerance, there has been limited investigation into the "evolution" of these two constructs as airline pilots progress in their careers. This project examines 16 pilots from two groups of different airlines (eight pilots for each airline) at four different stages of their careers (cadet pilots, second officers, first officers and captains) to determine: (1) Their understanding of risk and safety; (2) Risk perception and risk tolerance; (3) Comparison between the two airline pilots. Pilots were presented with a decision scenario during an approach and landing phase with aggravated conditions and conflicting requirements. A few additional general questions about their understanding of risk and safety were also asked. Results show that pilots from both airlines always prioritize safety and are aware of potential flight safety risks. However, not all risks are seen as equal, with some risks considered less impactful than others on their decisions. Their assessment and perception of risk vary according to their rank and experience. Risk tolerance among these pilots also changes accordingly. This research provided important insight into how airline pilots' risk perception and risk tolerance as they progress through their ranks. Additionally, pilots' feedback about the scenario and questions and discussions also revealed the importance and benefit of this type of training for the pilots, especially at the earlier stage of their career, to help enhance flight safety and decision-making. Although a general direction of pilots' risk perception and risk tolerance as they progress through their career may be seen, the current small sample size may be subject to misperception of some risks, indicating the limitations of this research.

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Acknowledgments

Author 1

I first came across Lund University in 2017 when visiting a friend pursuing a PhD. Intrigued, I explored the university's website and found the MSc program in Human Factors & System Safety, a field I had been researching in other universities. After a challenging yet rewarding journey, I successfully completed my thesis, broadening my perspective on Human Factors and Systems Safety.

I am profoundly thankful to our supervisor, Prof. Eder Henriqson, for his invaluable guidance, unwavering support, and crucial role in shaping the outcome of our thesis research. Additionally, I would like to express my gratitude to the examiner, Dr. Anthony Smoker, for his valuable input and assistance during the course, including his insightful comments.

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Author 2

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Chandrasegaran Mariappan

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List of Abbreviations

ADM	Aeronautical Decision Making
ATPL	Airline Transport Pilot License
CPDLC	Controller Pilot Data Link Communication
CPL	Commercial Pilot License
CRM	Crew Resource Management
FAA	Federal Aviation Administration
HES	Hazardous Even Scale
HF	High Frequency
IMC	Instrument Meteorological Condition
LOC	Locus of Control
LOSA	Line Operations Safety Audit
MEL	Minimum Equipment List
MPL	Multicrew Pilot License

NEXRAD	Next Generation Radar
NTSB	National Transportation Safety Board
PCE	Plan Continuation Error
PPL	Private Pilot License
SA	Situational Awareness
SHELL	Software Hardware Environment Lifeware-Lifeware
SMS	Safety Management System
SOB	Safety Operation Behaviour
TEM	Threat and Error Management
VMC	Visual Meteorological Condition
WRDM	Weather Related Decision Making

Introduction

Overview

Issues of risk and safety are of paramount importance in the field of aviation. Risk perception and risk tolerance play an important role in airline flight operations, both on each pilot's individual level as well as on the organizational level. Both constructs have significant implications for airline pilots, as they are responsible for the safety of their passengers and crew (Bell et al, 1995; Bishop et al, 2020).

Risk perception and risk tolerance refer to an individual's subjective evaluation and acceptance of risk (Slovic, 1987). These two constructs (risk perception and risk tolerance) have been suggested as explanations for pilots' poor decision-making and errors that resulted in a large percentage of fatal incidents and accidents (Hunter, 2002; O'Hare, 1990). Pilots must make decisions under conditions of uncertainty and must be able to assess and manage risk in a variety of situations. One explanation for behaviours that leads to an accident or incident is that the person did not perceive the risk inherent in the situation or cues, inaccurate assessment, or ignorance of the situation, and hence did not undertake precaution, preparation, avoidance, or other risk-mitigating actions to avoid hazards and threats (Charles, 2015). Another explanation is that when individuals correctly perceive the risks involved in a situation, some may elect to continue because the risk is not considered sufficiently threatening (Drinkwater et al, 2010). High-risk tolerance can lead pilots to choose courses of action that unnecessarily expose them to hazards and increase the likelihood of accidents (Ison, 2015). Those individuals would be described as having a greater tolerance or acceptance of risk, compared to the other pilots (Hunter, 2002; 2004; O'Hare, 1990). Inevitably, risk perception and risk tolerance are two related and often confounded constructs. Understanding and managing these two constructs (risk perception and risk tolerance) is crucial for ensuring the safety of airline operations.

Risk perception and risk tolerance remain a concerning issue for pilots in aviation. Perception of risk in a particular phase of flight is a foundational aspect of making the right

decisions within each pilot's rank and experience (skill) level. Past studies have always shown that pilots lack the ability or failure to recognize hazards and threats leading to poor risk perception and risk tolerance during operations that are attributed to human error, decision making, and reduced safety leading to an accident. (Charles, 2015; Hunter, 2002, 2006; Ji et al, 2007; Moses et al, 1989; O'Hare, 1990; Oranasu et al, 2002).

Having been airline pilots (from two different major international airlines) for almost 26 years each, we observed that our perception of safety and risk and our tolerances have in fact evolved over the years with increasing experience. Moreover, what would not have mattered much during our aviation infancy, begged to be evaluated and be seen with a more conservative or heightened sense of safety. From our own experience progressing through the ranks and observing other pilots at different ranks, we witnessed that as airline pilots progress through their career, from the ab-initio stage to becoming a senior captain, there are continuous changes in how they perceive safety. Besides that, there are also changes in tolerance levels during their operation.

Although there are previous studies on the topic of risk perception and risk tolerance of pilots, the transformation of risk perception and risk tolerance among airline pilots through their career progression still represents an under-investigated subject. Thus, our research question is:

> "How do airline pilots' risk perception and risk tolerance change as they progress in their careers?"

Objective

The objectives of this study are:

1) To explore the pilot's understanding of risk and safety at each stage of their career,
2) To investigate risk perception and risk tolerance among airline pilots at different ranks in a given scenario,
3) To compare and contrast risk perception and risk tolerance between pilots of two airlines.

Scope

The scope of the research is limited to studying 16 pilots from two international airlines. (Two pilots each from four different ranks - Cadet, Second Officer, First Officer, and Captain).

As safety encompasses many aspects, in this thesis we will limit the boundary of risk and safety to three areas: 1. Environmental (weather conditions), 2. Aircraft technical status (Instrument Landing systems) and 3. Personal background (experience and knowledge). This will ensure that we normalize the scope for ease of comparison (between the category of the pilot group and the two airlines) and to manage the thesis.

Literature review

Introduction

To achieve its high level of safety, aviation requires safety professionals to safeguard the system (FAA, 2019). It's desirable that the professional possesses good qualities, competence, and skill through which safe working practices are organized and delivered (Waring & Bishop, 2020). Pilots are in such a category. Failure to do so may have serious implication on their job such as the signal case of Lord Justice Denning involving the captain of a Viscount, which ran out of fuel. In the legal judgement, the captain, Mr Taylor was dismissed **(**even though Mr Taylor was a qualified pilot who had only made one mistake**)** due to "departure from a high standard of flying that may have had disastrous consequences, as the passengers and crew on board the flight could have been seriously injured or worse" (Brown, 1994). To ensure safety, their professionalism must be shaped from their early days as a trainee pilot until becoming a captain. The importance of this behaviour of being professional is emphasised and must be developed as they progress their career in an airline (FAA, 2016; Helmreich et al,1999). Their ability to manage risk and uncertainty and make appropriate decisions is based upon their knowledge and experience (Waring & Bishop, 2019; Wiggins et al, 2002; Kahneman, D., Slovic, P., Tversky, A., 1982, Klein et al, 1993; FAA ADM, 2019). This section covers these aspects and previous related research in the area.

Aeronautical Decision-Making (ADM)

Aeronautical decision-making is an important aspect of flying an aircraft, from the initial flight planning to the final approach, and differentiates between competent and expert pilots (Adams & Ericsson, 2000; FAA ADM, 2019). How risk is perceived and tolerated finally influences decision-making (Jensen, 1997).

The U.S. Federal Aviation Administration (FAA) Advisory Circular 60-22 defines aeronautical decision-making (ADM) as follows:

ADM is a systematic approach to the mental process used by aircraft pilots to consistently determine the best course of action in response to a given set of circumstances.
"The best course of action are decisions and action take to ensure safety and efficiency of the flight"
(FAA Advisory Circular 60-22)

Decision making in aviation is built upon the foundation of conventional decision making (FAA, 2019). However, ADM is a complex process as it is carried out in dynamic conditions, time constrained, with competing goals (safety, productivity etc) and complex environments that require real time solutions (Zsambok & Klein,1997, pp 3-16). It involves the cognitive process of selecting a course of action from among multiple and maybe changing alternatives. Due to this, the decision-making process in flying an aircraft produces a choice of action or an opinion that determines and indicates the decision maker's (pilot's) behaviour on risk taking and therefore has a profound influence on task performance and its outcome due to their risk tolerance levels.

One fact that is important in decision making is that it depends critically on the pilot's situational awareness (SA) with one of its main elements being the perception of the risks entailed by various threats in the environment during a flight operation. Here, SA refers to the perception and understanding of the current situation and the ability to anticipate future events in the environment as defined by Endsley (2017). It involves being aware of relevant information, interpreting its meaning, and accurately comprehending the context to make effective decisions and take appropriate actions.

The pilot's risk perception is influenced by various parameters such as experience, organisational policies, the environmental or technical conditions, and the human factors. With timely perception, a person will then be able to understand the relevance and importance of those cues to a person's goals and finally predict potential future events in the system. However, human

beings are not able to perceive, evaluate, understand, and act on all aspects of the cues (Wickens, Hollands, Banbury, 2015).

According to Tversky & Kahneman (1974), the decision maker must simplify reality (heuristics) and decide within it calls (bounded reality). At the same time, a set of decisions is made while seeking satisfactory results to a given situation (satisficing). A successful decision is not necessarily the optimum or most rational response action/decision. Most of the time trade-offs are required (satisficing decision) (Amalberti, 2002).

Two types of decision-making models are the naturalistic decision-making model proposed by Klein, Orasanu, Calderwood, Zsambok (1993) and the collective decision-making model (involving team members) (Urban et al, 1996) as an alternate for the more traditional approaches of decision making. These methods are used through experience gained overtime and when time are limited and demanding situation as in the case of making decision during an approach which requires quick decisions under uncertainties and dynamic conditions such as descent, approach, and landing in weather conditions and aircraft technical deficiencies.

Rhoda and Pawlak (1999) found that the thunderstorm penetration and deviation behaviour of commercial airline pilots was strongly correlated with precipitation intensity, geographic coverage of precipitation, and range from the destination airport. Pilots frequently penetrated heavy precipitation near the destination airport and that they were more likely to penetrate intense storms when they 1) were following another aircraft, 2) were flying after dark, 3) had been delayed by 15+ minutes during the current leg of flight. Further, analysis by McCoy & Mickunas (2000) indicated that accidents that occur in bad weather are due to plan continuation errors (PCE). Data obtained from ASRS incident reports concerning weather related decisions reflected PCEs and some pilots themselves said that "they should have done something differently" (Oranasu, Burian, Hint, 2001). Thus, it is very important that the pilot understands the risks (with timely perception), able to tolerate the risks accordingly and apply the decisions effectively in the context of the situation especially when time pressed with ambiguous

cues to assist in reducing incidents and accidents and improving flight safety (Hoc & Amalberti, 1995). It is also very important for the organization especially the managers to understand the importance of local rationality (the inside perspective) among pilots who are facing the real conditions and how these forms the perspective of the situation and manage the risks with the available resources for a safe outcome.

The decision-making process is context dependent. Different strategies will be used depending on the type of decision being made (Orasanu, 1993), context (e.g., perceived relevance of the information and framing of the question (Rohrbaugh & Shanteau, 1999), personal variables (e.g., pilot experience, training, & current health (Mosier, 1991; Rohrbaugh & Shanteau, 1999), and the operational environment (e.g., whether civil or military, GA or commercial, & crew size (Mosier. 1991). Decision-making strategies differ according to the experience and expertise of the pilot. Experienced crews and pilots tailor their decision strategies to suit the situation, using heuristics or analytical strategies depending on the amount of time available (Orasanu & Fischer, 1997). Since decision-making is dependent on context and personal factors, training organisations should not prescribe one decision-making strategy to all situations and all pilots (Mosier, 1991; O'Hare, 2003; Orasanu, 1993).

Safety, Risk Perception & Risk Tolerance

Safety is defined as a condition of being protected from or unlikely to cause danger, risk, or injury (Oxford Dictionary). According to ICAO SMS Manual (2013), Annex 19, safety is the state of the aviation system or organization in which the risks associated with aviation activities related to the operation of aircraft or directly providing such operation are reduced to an acceptable level and monitored continuously. It is an important and the main component of any aviation organisation to ensure business continuity and sustainability and requires commitment from all levels of an organisation. As a summary we can conclude that safety is the overarching concept that encompasses the state of being "safe," where risks associated with aviation activities are reduced

to an acceptable level and continuously monitored to ensure a secure and sustainable aviation operation.

Hence, safety is inevitably closely related to risk as its main component. Safety Management Systems (SMS) are the principal way aviation organisations implement and manage their safety levels through policies, standards, oversights, and procedures (ICAO SMS Manual).

Risk is ubiquitous. The dictionary defines the word 'risk' variously as:

- A hazard, danger, chance of loss or injury,
- The degree of probability of loss,
- A person, object, or factor likely to cause loss or danger,
- To expose to danger,
- To incur the chance of an unfortunate consequence by some action,

According to ICAO Annex 19, risk is the assessed potential for adverse consequences resulting from a hazard. Hazards can be internal (cognitive and physical – human factors) or external (environmental-weather) or technical related.

From the above definitions, risk, can be summarised as the probability of injury or loss of life (negative consequence) covering the probability of encountering a hazard (independent of the nature of the hazard) and the severity of a hazard (Sanders & McCormick, 1993 & ICAO SMS, 2013). It can be summarised as:

$$\text{Risk} = \text{Probability} \times \text{Severity}$$

Another definition of risk as per ISO 31000 (2018), risk is "The effect of uncertainty on objectives". Hillson (2016), also known as the "Risk Doctor" summarises risk as "uncertainty that matters". According to Hillson, something matters if it has an impact on objectives. Risk has

positive (opportunities) and negative (threats) effects. Combining both we can then say that risk is a function of uncertainty and objectives.

$$\text{Risk} = f(\text{Uncertainty, Objectives})$$

This definition can be related to the presented scenario when the pilots need to make decisions in an uncertain condition and their objective.

Although risk-taking can potentially result in positive and negative outcomes, most of the researchers focused on its negative, not positive manifestations (Fryt & Szczygiel, 2021). Positive risks are risky because of the variability and uncertainty of their potential outcomes (Figueredo & Jacobs, 2010).

How a person perceives risk is inherently subjective based on one's experience (personal and work), exposure (familiarity), knowledge, policies, and training influence the awareness of the pilots over time of the risk involved and the tolerance level. A certain degree of risk must be accepted with trade-off between safety, production, and any other elements that are important to them in time and space with minimal potential consequences (ISO 31000, 2018; Dekker & Nyce, 2014).

Two aspects that are looked at in this research are (a) the pilot's perception of risk and (b) how this mould their risk tolerance behaviours towards a safe or unsafe flight operation. These are two constructs that are related and often confounded. This is due to the complexities in which these judgments are made (Hunter, 2002).

In general, perception can be termed as an ability to see, hear touch, taste, and smell, thus, to appreciate and being aware of something to gain information to give meaning and significance to sensations. (Stranks, 2007; Lexico, n.d). In other words, how a situation or phenomenon is understood and interpreted. Perception is a complex mental function. It is a cognitive ability to discern the risk inherent in a situation. This requires the ability to appraise both the external situation and one's personal capacities (Hunter, 2002).

Risk perception plays a vital role in hazardous flight situations, enabling pilots to evaluate circumstances and make critical judgments. Any under or over-estimation may result in varying degrees of compromising safety. Thus, a high level of safety (risk) perception requires the pilot to accurately appraise the situation and act accordingly (Ji et al, 2018). In flight operations, this involves how the pilots' knowledge, experience, assumptions, and beliefs are used to process and interpret the situation, thus shaping their perception of safety. Inappropriate risk perception may compound the risk assessment due to incorrect interpretation of significant cues. Perception of risks and the decision that follows are influenced by both individual cognitive factors as well as organisational policies, requirements, economics, and safety culture (Oranasu & Fisher, 2002). These can create dilemmas for flight crews. Ngyren (1995) also pointed out that risk dimensions are additive. This means that as the threats increase, decision-making becomes more difficult.

The decision of the amount of risk (tolerance) that a person is willing to take largely depends on one's perception of the risk that influences the risk tolerance level. Hunter (2002) proposed that risk tolerance can be conceptualised as a personality trait.

Pauley (1990) conducted research to assess risk perception and risk tolerance among pilots using scenario-based (weather) measures. The result showed that twelve pilots continued beyond the critical decision point, 18 pilots diverted, and 2 pilots crashed. It was found that there was no relationship between in-flight Weather-Related Decision Making (WRDM) and expertise in weather-related risk perception. However, the pilots who diverted gave higher ratings of risk during the Cochran-Weiss-Shanteau (CWS) task (degree of risk perception index) compared to the pilots who crashed. The pilots who diverted also tended to be more risk averse and implicitly perceived more risk in adverse weather, compared to the pilots who continued, suggesting a relationship between risk management and decision-making in a simulated flight into adverse weather.

In the case of the descent, approach, and landing during bad weather conditions, plan continuation errors (PCE) occur because pilots may underestimate the risks inherent in a

dynamically changing situation or because they overestimate their own capability to deal with the situation (Orasanu et al, 2001). Personal biases may also influence their perception and following decisions. Pilots may tend to believe they are more skilled or more in control of the situation than they are (Taylor & Brown, 1998).

Despite its significance to aviation flight operations safety, there is surprisingly little empirical research on the role of risk perception and risk tolerance in pilot decision-making. Most of the current work deals with general aviation pilots and is confined to individual airlines and none that looks at the transformation throughout the career of the pilots. Our research is aiming to provide some initial insight into airline pilots' decision-making by how they perceive the risk and how much tolerance they take.

Pilots Risk Assessment & Risk Management

Every flight has some potential threats, hazards and some level of risk associated with it. Thus, it is critical that pilots are able to assess the risk involved and differentiate, as far in advance as possible, between the level of risks involved ranging from low risk to a high-risk flight/situation.

Risk management is a key component of aeronautical decision-making and one of the possible causes of "pilot error" (Jensen, Guilke, Hunter, 1997). Risk management encompasses risk perception and risk tolerance. Managing the inherent risk is key to flying safely and further reducing the number of incidents. Risk management includes the development of personal minimums, which is the maximum level of risk that the pilot feels that he or she can handle, and awareness of potential hazards and how they can affect the safety of the flight (Shappell & Wiegman, 2000).

According to Lopes (1987), individuals with a high tolerance for risk are primarily driven by the potential opportunities or gains that come with taking risks. On the other hand, individuals who are risk-averse are motivated more by the potential threats or losses associated

with taking risks. In the context of pilots, it was observed that they tended to be more risk averse, with their decision-making influenced by the perceived threats involved. This inclination towards being cautious can be seen as a positive personality trait, as it contributes to enhancing safety.

According to National Transportation Safety Board (NTSB, 2009) statistics, in the last 20 years, approximately 85 percent of aviation accidents have been caused by "pilot error" and many of these accidents are the result of the tendency to focus flight training on the physical aspects of flying the aircraft (by teaching the student pilot enough aeronautical knowledge and skill to pass the written and practical tests). Further, according to FAA (2017), if risk management is ignored, it could sometimes lead to fatal results. Although we do not agree with NTSB's statement on pilot error, we do agree to their suggestion that integrating risk management into flight training teaches aspiring pilots how to be more aware of potential risks in flying, how to clearly identify those risks, and how to manage them successfully.

"A key element of risk decision-making is determining if the risk is justified." (FAA, 2017)

The risks involved with pilots flying an aircraft can be different from day-to-day flying operations. Managing these risks requires a conscious effort and established standards (or a maximum risk threshold). Pilots who practice effective risk management have predetermined personal standards and have formed habit patterns and checklists to incorporate them (FAA, 2017).

Personality traits and safety behaviour

Personality traits can be used as a prediction for the pilot's safety behaviour (Hunter, 2005). Behaviour means how one's attitude or approach is moulded or characterised (Macrae, 2009). One's personality and attitude are formed and modified over time through personal experiences, knowledge, and social interactions that shape their assumption and beliefs (Bell et al, 1995). This can influence their risk perception, risk tolerance, decision making and finally leading to involvement in aviation accidents (Ji et al, 2011). Pilots are constantly presented with risky

situations in most part of their daily flight operations that are influenced by their behaviour due to their personal traits, especially if the pilot is a risk taker.

Research has shown that it is important to understand how the constructs of personality traits and variances influence risk perception, risk-taking behaviour, and operational decision making to improve safety (Hunter, 2005; King et al., 2003; Lubner et al., 2001; Platenius & Wilde, 1989; Sanders & Hoffman, 1976).) The relationship between personality type, risk tolerance, safety behaviours, and decisions in aviation has been examined since the 1950s when personality assessments started to be used for the recruitment and selection of air traffic controllers, pilots, and other safety-critical personnel (King et al., 2003; Taylor, 1952).

Several researchers identified that individuals who are either overconfident or lack confidence in their abilities, understanding, perceptions, and performance can pose a severe threat to safe aviation operations (Drinkwater & Molesworth, 2010; Orasanu et al., 2002; Sulistyawati et al., 2011). According to their research, the bipolar effect of confidence influences their behaviour which could impair risk perception, flight operational judgments, and situational awareness in several situations. Further, it may also affect the other team members, resulting in overall poor performance of the mission. According to (Winter et al, 2021), personality significantly influenced risk perception, while self-confidence was a significant mediator. Their research data indicated that high self-confidence might result in reduced perceptions of levels of risk.

Thus, while working on improving system resilience (pilot and operations), personal traits and attributes involving a flawed judgment/perception of threats, hazards, and risk (tolerance and behaviours) had remained as central focal point of accident prevention research (O'Hare, 1990; Molesworth et al., 2006).

There has been an increase in the use of behavioural safety or behaviour modification approaches (Krause, 1996). These interventions generally involve the observation and assessment of certain behaviours, usually those of front-line personnel (The specific origins of

these approaches can be traced back to the 1970s and 1980s when researchers and practitioners began to recognize the importance of human behaviour in workplace safety (Krause, 1996). The rationale behind behavioural safety approaches is that accidents are caused by the unsafe behaviours of front-line staff (Anderson, 2020). From the context of our proposed thesis, we intend to evaluate how a pilot's behaviour evolves with the progression of a pilot's career (from single, smaller aircraft to multicrew and larger aircrafts and through their rank) and influences their risk perspective and tolerance and ultimately affecting the operations and flight safety.

Previous researchers related to pilot's risk perception and tolerance

Pilots' risk perception and risk tolerance have been studied by many researchers. One of the earliest and most prominent researchers in this topic that has been referred to by many other researchers was the work done by Hunter (2002, 2004, 2006, 2011). As a result, most of the current research related to these topics may be viewed as a replication-extension of Hunter's research. Amongst his findings, Hunter (2002) mainly concluded that risk perception is a cognitive activity and tolerance on the other hand as a personality trait. Hunter, (2006) also investigated how risk is viewed by a third person (another – fictional pilot) compared to the person who has himself involved in an incident or accident previously. The finding shows that pilots' or drivers' involvement in an incident, accident or hazardous situation provides a higher perception inherent in a situation of future risk and better decision making to avoid or take risk mitigation actions. In the same report, Hunter also reported that "participants who exhibited greater safety orientation tended to rate the situations as higher risk". Participants who have been in hazardous aviation events tend to (a) rate the scenario as lower in risk, and (b) had a more inaccurate estimate of the safety level. Hunter also considered several demographic factors and found that pilots' age significantly influenced the way pilots perceive risk: "Within the category of private pilot license certificate holders, risk perception accuracy score changes with age, with younger pilots having a more accurate view of the flight risk than older pilots.

Hunter's studies were extremely beneficial and important to previous and our research as it identified the key factors to target and triggered the idea for us to extend his research which was primarily targeted at general aviation pilots to airline pilots. In line with this viewpoint, our research, in a way has elements of Hunters research too, by examining in part, the relationship between pilots' risk perception and their risk tolerance. However, in this research, we are looking at airline pilots and their progression.

Research by Landry (2006) and Rowe & Wright (2001) has shown that the perception of risk is based on an individual assignment or task which is dependent on the characteristics of an individual and the characteristics of the risk itself. Studies between experts and laypersons have indicated multiple social and demographic factors that can influence risk perception. Rowe and Wright (2001) argued that for the most part, other research has ignored age, gender, education culture and socio-economic status which provides for the methodological weaknesses that can influence the results of the research. Li et al (2003) studies on age, flight experience and risk of crash involvement among pilots (commuter air carrier and air taxi) show that crash risk remained fairly stable as the pilots aged from late forties to their fifties. The same research also shows that pilots who had between 5000 and 9999 total flying hours had a 57% lower risk of crashes than their less experienced counterparts. It then levels off once the flight experience passes 10000 hours. They have also found that risk of crash involvement decreases in a non-linear fashion as total flight time increases especially safety benefit is pronounced in the early, experience building stage. In short, as pilots gain more experience, their risk perception and tolerance vary accordingly.

Other research by Thomson et al (2004), compared risk perception between experts and novices in helicopter operations. Their study reported evidence of the perceptual differences between the two participating groups. They found that an expert's perception of relative risk is more veridical. A significant positive correlation between the flight hours and the contextual risk-taking taking tendency was also shown, leading the experienced pilots' choices towards risky

alternatives, potentially due to their overconfidence based on superior task performance. Novices tend to be guided more by human factors such as stress and crew coordination while the perception of experienced pilots appears to be influenced by task-orientated factors. Another area contributing to the risk perception is learnability by both groups. Besides aviation, other areas such as business (Yordanova & Matilda, 2011) and investment (Bashir et al, 2014) also have these elements of learnability.

Drinkwater & Molesworth (2005) investigated if known factors such as flight experience or age, in addition to personal characteristics such as risk perception and how it could predict pilots' willingness to engage in risk-taking behaviour among Bachelor of Aviation students. They reported the students' pilots were clearly able to distinguish between risk perception (those students elect to undertake risky flight) and those who did not. They also reported that "recognition and perception of immediate risk in aviation are related to behaviours that attempt to minimize risk to the lowest possible level" rather than the traditional measures of pilot competence such as flight experience, age and flight performance. It was also found that older pilots were willing to engage in riskier flights and risker behaviours.

Charles (2015) examined the effect of experience and personality of pilots on risk behaviour using Hunter's (2002) Risk Perception Scale. He reported that risk perception was significantly related to flight time and level of certification achieved. Pilots' experience and risk perception were inversely related which shows that age does not have a direct relationship with risk perception. Charles concluded that the relationship between risk perception and risk-taking (tolerance) is complex and possibly confounded. These studies show that there is a relationship between personal characteristics and risk perception.

Pauley et al (2008) examined pilots' attitudes and the role of risk perception and risk taking in both visual (VMC) and instrument (IMC) weather-related scenarios using Hunter's (1995) Hazardous Even Scale (HES) which asks participants to self-report the number of times they had been involved in 12 different aviation events. Language usage related to risk (danger,

threat, harm, lethal and hazard) and safety (protected, secure, home, reliable and sure) were observed. The findings from this research show that qualified pilots associated IMC with risk and VMC with safety. This suggests that implicit processes may play a role in aeronautical decision making. In the related study, it was also found that there was a significant relationship between anxiety and previous involvement in hazardous weather events towards risk perception and tolerance. Pilots who see less risk and feel less anxious about adverse weather are more likely to experience a greater number of hazardous events compared to pilots who perceive more risk and feel more afraid of adverse weather. These findings prove the relationship between risk perception and pilots' involvement in hazardous events.

In other research undertaken, Knect (2015), investigated how graphical weather displays such as Next Generation Radar (NEXRAD) with different weather condition displays (representing the risk gradients) and flights paths from departure to destination through these varying weather conditions (displayed by three colour schemes) are related to GA pilots risk tolerance based on flight path length (a measure of efficiency) and highest-risk area traversed (safety measure). The findings from this work showed tactical risk-taking and that higher motivation led to shorter flight paths, pilots exhibited tolerances in excess of the policy goals and the numerical risk values themselves sometimes confuses many of the pilots. He suggested that these findings can be effectively and easily addressed by training such as using simple heuristics, and simplifying mental rules which substitute for complex mental calculations.

Green (2001) reported that although aviation is considered a high-risk activity, flight instructors that she interviewed in her study said that flying is not a risky activity. According to Green, this is because the flight instructors did not recognize the risk inherent in aviation, assuming competence in routine procedures will suffice in achieving an accident-free career. Green describes this behaviour as "risk denial," where instructors, by engaging in such denial, may unintentionally neglect the importance of addressing potential pitfalls in their instructional design process. Risk denial allows practitioners to view flight as merely the implementation of

technical procedures that, if done correctly, eliminate the potential for risk and downplay the role of good pilot judgement. These findings suggest an apparent disconnect between reality and perception of risk among flight instructors as an important point as it relates to instructional choice and strategies that instructors impart to their students. Pilots' attitudes and behaviour about risk are developed early in the flight training and adequate training on what constitutes a risky situation is critical for successful training and the safety of the operations. Thus, the instructor's duty is essential and should occur as early as in training possible. Our research will include this element as one of the questions and endeavour to obtain some insights into airline training.

Hong et al (2016), examined airline training pilots survey data to determine how pilot students' years of education and the institution they attended affect their perception of the risk factors in aviation using the SHELL model. The results revealed that student pilots lack confidence with respect to their knowledge during flights, moreover they fail to recognise the importance of maintaining supporting staff involved in the flight process. Their conclusion is that as the demand for more pilots increases, the newly approved training centres must foster interaction between human factors and other aspects of aviation safety and more standardised curricula. Salas et al (2001), proposed that flight training programs must promote error avoidance, and early error detection and minimise or manage the error consequences when they occur. The importance of training pilots regarding risk perception and risk factors cannot be overemphasized because they will endure overall safety. In our research, both airlines investigated, have their own well-established pilot training school. The cultural differences between these two organisations in training, risk perception and tolerance may be identified.

Risk tolerance is an important issue for safety professionals who face workplace risk such as the pilot community. Risk tolerance may be mediated by both the general tendency of risk aversion of the person and the personal value attached to the goal of a particular situation (Hunter, 2002). One example from research by Knecht (2015), mentioned earlier, is when pilots

continue into adverse weather, maybe because they are willing to accept the risk of in pursuit of their goal of completing their mission and arriving at their destination (press-on-it is). The high-risk tolerance can lead to pilots to choose courses of action that unnecessarily expose them to hazards and increase the likelihood of accidents. Ji et al (2011), studied the personality approach and social cognition approach to investigate the relationship between risk tolerance, risk perception, hazardous attitudes, and safety operation behaviour in order to understand the mechanisms underlying commercial pilots' safety operations in aviation. Their result showed that risk tolerance has an indirect effect on safety operation behaviour by influencing hazardous attitudes. Ji et al (2011) also found that risk perception has a significant moderating effect on the relationship between risk tolerance and safety operation behaviour. They concluded that low-risk tolerance primarily influences safety operation behaviour indirectly by affecting hazardous attitudes. With risk perception increasing, the negative effect of risk tolerance on safety operation behaviour is gradually reduced.

Ji et al (2018), investigated the relationship between the personal trait, mindfulness (attention to and awareness of present events and experiences), risk perception, flight experience and incident involvement among commercial airline pilots in China. The result showed that trait mindfulness has a direct and negative effect on airline pilot's incident involvement and an indirect effect on incident involvement through influencing risk perception. Further, they have also reported that flight experience strengthens the negative and direct effect of trait mindfulness on incident involvement. Based on these conclusions, they suggested that increased efforts on airline safety campaigns should be aimed at adopting a candidate selection process that incorporates the psychological aspects of testing for trait mindfulness, changing airline pilot risk perception related to hazardous events and carrying out programs of mindfulness to promote airline pilots' safety behaviour and avoid human error to reduce the involvement of more experienced and less mindful pilots. In another research, You et al (2016), investigated the relationship between Locus of Control (LOC), risk perception, flight time and Safety Operation Behaviour (SOB) among

airline pilots. LOC refers to the degree to which people perceive that the outcome of the situations that they experience are under their control. It can be influenced by own effort (internal) or environmental forces (such as weather) that are beyond one's control (external). The findings show that internal locus of control directly affected pilots' safety operations behaviour. Risk perception seemed to mediate the relationship between LOC and SOB, and total flight time moderated internal locus of control. In another word LOC primarily influences safety operations behaviour indirectly by affecting risk perception and the total effect of internal LOC on safety behaviour is larger than the external LOC. Further, the benefits of flight experience are more pronounced among pilots with higher internal LOC in the early and middle building stages.

The aviation industry has transformed over recent decades. To protect and improve aviation safety, we must understand the pilots' perspective and behaviour as they are the last line of defence. The available literature on safety and pilot behaviour was carried out on airline and general aviation pilots age and experience (flight hours) at a certain point of time (discrete) with limited research for the trainee (ab-initio) pilot group.

Our proposed thesis aims are to address the research gap that we have identified by conducting a comparative analysis of data from two airlines that operate in different regions or countries, which we refer to as "demographically variant airlines." Previous studies have examined risk, safety, and pilot behaviour separately, often focusing on specific points in time or specific pilot communities especially general aviation pilots in Western countries. This leaves a gap in research regarding these issues specifically for airline pilots throughout their careers.

Existing literature reveals that past research on pilots' safety perception and behaviour has primarily focused on discrete time points, general aviation pilot communities, or single airlines. Some studies have used computer-based exercises that do not fully capture the complexities of real-flight operations. As a result, there is currently a lack of research available to compare the safety, risk perception, and risk tolerance behaviours of pilots as they progress throughout their careers and between different airlines.

Therefore, our thesis seeks to fill this gap by conducting a comprehensive analysis that considers the evolving safety, risk perception, and risk tolerance of airline pilots, considering the demographically variant environments in which they operate. By examining data from two distinct airlines, we aim to provide valuable insights into how these factors vary across different regions and how they may influence pilot behaviour and decision-making in real-world flight operations.

Methodology

Research Design

This research employed a multi-case study approach with a focus on two major airlines. Airline X is based in Southeast Asia and flies to more than 100 destinations around 30 countries. Airline Y is based in the Middle East. Prior to suspensions due to the COVID-19 pandemic in March 2020, their global network spanned more than 150 destinations in more than 80 countries. The airlines have their own cadet pilot training scheme with well-established ab-initio flight training schools, training departments and command upgrade (command training) programs. Most of their cadet pilots and co-pilots (second officer and first officers) are trained and upgraded within their own airline system. Both airlines have excellent safety track records throughout their combined years of operations (for almost 80 years) with each only having one major accident against aviation industry standards. Airline X consists of mainly local citizens with few neighbouring country's pilots while Airline Y, First Officers and Captains are expatriates from almost 100 countries.

Data Collection

A total of 16 pilots from two different international airlines (8 pilots for each airline which is represented by 2 pilots in each rank category) were interviewed. We identified potential pilot interviewees from each category of the ranks and at this time most have agreed to be interviewed. We endeavoured to select pilots from different fleets, age, and years within each category and both line pilots, instructors, and management pilots. Before commencing the interview, we explained the interview aims and its process and further obtained signed consent protocols from them.

The research was primarily conducted using a qualitative approach employing an interview technique based on a scenario (A hypothetical decision scenario during an approach

and landing phase with aggravated conditions of weather and technical issues presented to the pilots) which is developed by Hunter (2002) and moderated by our own experiences. The questionnaires were divided into 3 sections as described in the next section. This same scenario was used for all the pilots' groups which allowed us to compare the answers of different groups of pilots. Hence making the entire investigation more reliable and valid.

Part A consists of closed-ended questions to collect demographic information. Part B and C is the interview with open-ended questions to encourage some discussion and to allow the participants to think aloud of their considerations to form the perception of the situation and make appropriate decisions based on their risk tolerance levels. Some questions are unique to the categories of each pilot group included. The list of questions is attached in appendix 2. Table 4.2 shows the comparison of safety perception and risk tolerance between the two airlines. During the interview process few other questions we asked a few other questions or provided examples to guide the pilots if they either did not understand our questions or deviated from the objective.

As far as possible the data collection was conducted face-to-face during an actual flight to ensure the best feedback. We ensured that the interviews were only conducted during low workload periods in cruise (for example during CPDLC and HF radio communication) and good weather conditions. However, we also either conducted the interviews via phone or video conferencing (google meet). We interviewed 7 pilots together to ensure standardization. The rest of the 11 pilots we interviewed separately. Inflight interviews were conducted in segments and face to face and video were conducted continuously. Each interview took approximately about one hour collectively to complete. Both the questionnaires and interviews were recorded for processing. Further, the reaction (body language and the tone of the respondents) of the pilots while answering the questions was also observed and noted. The sample questions compilation is included at the end of this proposal (Appendix 2).

Further to this, we reviewed both airlines' safety, policy, and training-related flight operations manuals, including the Crew Resource Management (CRM) documents, Minimum

Equipment List (MEL), airlines policies (normal procedures, weather deviation etc) and data from Line Operations Safety Audit (LOSA) reports with particular attention given to the safety and risk related issues.

Finally, our personal experiences of going through the whole process from being a cadet pilot, going through the ranks over the years and finally being promoted as a captain (as an auto-ethnographer) were used for comparison with the interview and feedback data to ensure the validity of the collected data. With our own experience, were able to control the discussion to be within the research topic and filter the necessary data.

Data Analysis

Written notes and video/voice recordings were taken during every interview. Interview data were coded using a multi-step, iterative process following Corbin and Strauss (2008). The data analysis was used to make sense of the collected data. Descriptive and thematic analysis was used for this process. It involves reading the transcripts and notes and listening to the interview recordings to familiarise and understand the overall data.

Descriptive analysis was used to describe the basic features of the raw data in the study to provide descriptions of the population (pilots) through numerical calculations or graphs or tables. They provided simple summaries about the sample and the measures of the data that will assist in presenting the data in a more meaningful way, i.e which allows a simpler interpretation of the data. Some of the basic categories of descriptive statistics are measures: measures of central tendency (mean, mode, median) and measures of variability or spread (variance and standard deviation) of the pilot community that is used in the research.

In the thematic analysis, the data from questionnaires and interviews were closely examined using both inductive and deductive methods and grouped within the respective categories according to identify common themes – topics, ideas, and patterns of meaning that

come up repeatedly. It was used to understand pilots' views, opinions, knowledge, experiences or values regarding risk perception and risk tolerance among the pilots.

All three separate datasets that are collected from the questionnaire & interview, manuals and documents and our own knowledge and experience were finally used to validate the separate data through the convergence of information from different sources to answer the objectives and research questions that are formulated. This was carried out through triangulations (3 different sources of information) to develop a comprehensive understanding of the objectives of the research.

Ethics Consideration

Ethical considerations concerning the participants in the research are guided by Lund University Research Ethics (https://www.researchethics.lu.se/). Throughout the research project, we maintained good research ethics.

One of the main issues during the establishment of the methodology is obtaining permission from the pilots to conduct the research. Permission was first requested from the airline. However, due to issues of confidentiality, we decided to approach individual pilots those willing to voluntarily participate in the qualitative research (interview). Many of the pilots turned down our request because of fear that the replies may affect their careers. As this was during the mid Covid 19 phase, pilots were sceptical in participating in our interviews. This condition delayed our data gathering for this project. Due to the reasons stated, we decided not to name the airlines, instead named the airlines as X and Y. There were no any financial or 'in kind' reimbursements or inducements offered to pilot participants.

The structure, purpose (objective), scope, nature as well as contextual use of their involvement in the interview was explained to the pilots. Statements and quotes will only be used in a way that ensures anonymity and solely after receiving acceptance from the involved participant. The interviewees were informed about confidentiality, clarifying the anonymity of the

airline and the geographical position, including names and certain positions mentioned during the interviews. During the transcription process, all names and certain sensitive positions are represented by numerical codes to protect the interviewees from harm or wrongs (Swedish Research Council).

All participants were presented with and signed an informant consent form adhering to the layout and guidelines issued by Lund University (Appendix 4) before starting of the interview. The investigator of this study will co-sign the consent forms and a copy of each is stored with all the research data. Informed Consent Form contains the following information:

- The plan for the research
- The purpose of the research
- The methods that will be used
- The consequences and risks that the research may entail.
- The person responsible for the research
- That participation in the research is voluntary, and
- That the research volunteer has the right to terminate his or her participation at any time.

Ethical procedures were followed to ensure the protection of participants' rights and confidentiality. The purpose of these forms was to provide detailed information about the study, including its objectives, procedures, and potential risks or benefits. Participants were required to read and understand the contents of the consent forms before providing their acceptance and approval. After the completion of the interviews, Signed Informed Consent Forms together with the data collected for each participant were either copied or sent to them via e-mail.

Prior to publishing the findings, the researcher will seek acceptance and approval from the participants to ensure their informed consent for sharing the results in the format required by

Lund University. This step is essential to respect the participants' autonomy and uphold ethical standards.

As part of participant engagement, pilot participants were given the option to receive recordings and/or transcriptions of their interviews, allowing them to review their contributions and provide feedback. Additionally, they were offered the final report of the study upon its completion. This approach promotes transparency and enables participants to stay informed about the research outcomes.

To uphold confidentiality and privacy, all recorded interviews will be securely destroyed at the conclusion of the research project. This measure ensures the protection of participants' identities and prevents any unauthorized access to sensitive information.

Throughout the research process, building a positive and trusting rapport with the participants was considered of utmost importance. This approach fostered open communication, encouraged participants to share their experiences and perspectives, and contributed to the overall validity and reliability of the study.

Results

Introduction

This section presents the data collected based on pilot interviews in 3 sections. A: Demographic, B: Scenario discussion and C: General Safety and Risk discussion. Detailed transcription of the interview results is attached in Appendix 3.

Demographic

A total of 16 pilots from two airlines were interviewed. Eight pilots from each airline, two pilots representing the four groups (Cadet pilot, second officer/junior first officer, senior first officer, captain). These pilots were coded (prefixed with X for airline 1 and Y for airline 2) as shown in Table 4.1. In airline Y, there are no second officers. After completing cadet pilot training, they are promoted as junior first officers. For standardisation for both airlines, the term second officer (abbreviation YSO) is also used to represent junior first officers in airline Y.

Table 4.1:

Coding of pilots according to rank and airline

Rank/Group	**Airline X (Pilot1/Pilot2)**	**Airline Y(Pilot1/Pilot2)**
Cadet pilot (ab-initio)	XCP1, XCP2	YCP1, YCP2
Second officer/Junior First Officer	XSO1, XSO2 (Second Officers)	YSO1, YSO2 (Junior First Officers)
Senior First officer	XFO1, XFO2	YFO1, YFO2
Captain	XFO1, XFO2	YFO1, YFO2

The results for part A: The demographic of the pilots for each airline is presented separately. Demographic data is for both airlines is tabulated and presented in Appendix 1 (Airline X) and Appendix 2 (Airline Y).

Airline X (Reference Appendix 1A)

For Airline X, four of the interviews were conducted in the cockpit, two face to-face and another two via video (google meet). The average interview time was 47.5 minutes. The second

officers' interview times were slightly lesser, and as the rank progressed, slight increases were noticed. The captain's interview times were almost 60 minutes. We capped the maximum interview time to 60 minutes. Of all the pilots interviewed in Airline (coded as X), 50 percent of the pilots were single (cadets and second officers), and the rest were married. Six out of the eight pilots held a bachelor's degree (mainly engineering related) and most of them has previous working experience before becoming a pilot.

The cadet pilots and the second officers are in the training stages. Cadet pilots were at the private pilot's license stage (PPL), and the second officers were with the multi-crew pilot (MPL) qualification. First officers and captains held the older (traditional) Commercial Pilot License (CPL) and Airline Transport Pilot License (ATPL). The age of the cadet pilots and the second officers were almost the same (average) 32 years old. The first officers were slightly older, and the captains were in their mid to late 50s. Only one senior first officer and one of the captains held both training (a supervisor role) and management position.

All the pilots are rated in both Visual and Instrument Flight rules (VFR/IFR). The pilots' years in the airline range from 3 years to 43 years. For all the pilots, their duration in the particular rank is almost half the duration in the airline. This corresponds with a total hour of about 61 hours for the cadet and almost 22000 for the senior captain. Types of aircraft also flown, in general, corresponds to the years in the airlines and total hours. Most of the pilots have experience flying different types of wide-body aircraft. The more years spend, the more aircraft types flown increase.

Airline Y (Reference Appendix 1B)

Two interviews were conducted via Google Meet, whilst the rest of the six interviews were face-to-face and in the cockpit. They averaged around 50 minutes each. The Captains' and the Senior First Officers' answers were more elaborate as they tended to ask more questions pertaining to the scenario. They tend to gather more information before coming to an informed

decision. Hence, the slightly longer interview times. Generally, the Captains and the Senior First Officers had more exposure to such scenarios.

The more junior the pilots, namely the cadets, are still single, unlike the other categories, who tend to be married or divorced (with children). The cadets' age ranged between 24 to 26 and are actively under training, while some are not exposed to line flying yet. Despite this, they do possess Frozen ATPLs. The junior first officers are slightly older, around 26 to 30 (For this research, they are grouped as second officers, YSO). The Senior First Officers and the Captains' age gaps are rather narrow, with the Senior First Officers being between the age of 35 to 41 and 43 to 48, respectively. The tertiary educations vary, while one Senior First Officer holds a medical degree and is a practicing doctor previously. None of the pilots interviewed in Airline Y held any training or management posts.

All the pilots have ATPL, hence rated for VFR and IFR (Visual and Instruments Flight Rules). The pilots' years in the airline range between 2 to 15 years. Most of the Senior First Officers and Captains hired are expatriates with various levels of experience ranging from 11 to 22 years. Pilots from both ranks are from various countries, while the cadets and the junior first officers comprise the host nation's citizens. One of the captains was hired directly into his position, while another captain underwent a tedious in-house Command Upgrade programme. Except for the cadets' pilots, all the other pilots interviewed are flying the B777 aircraft type. Total flying hours range from 300 to 15000. However, the first officers and captains in Airline Y, on average do more flying hours in a month compared to Airline X pilots. Their rest hours in the bunk it's not logged.

Scenario

In this section, the discussion focuses on three primary open-ended questions, along with their respective sub-questions, which were based on the scenario provided in Appendix 2. The responses from the pilot participants, including cadet pilots, second officers, first officers, and

captains, were analysed and grouped according to their rank, encompassing both Airline X and Airline Y.

<u>Question 1:</u> Pilots' overall view/understanding of the situation (scenario) presented, their considerations (goals, priorities, objectives) and resources used.

Despite their limited experience, the cadet pilots demonstrated critical thinking skills and situational assessment by considering important factors such as weather conditions, equipment malfunctions, and passenger safety in their responses. XCP1 was concerned about the challenging weather conditions and the safety of the approach: "From the scenario presented, what strikes me first is the weather condition. The thunderstorm at the approach path 'scares me'... I am worried if I can land safely." XCP2, with limited flying experience, acknowledges that he may need assistance and highlights the need to consider other available resources: "With my limited flying experience, I have not seen this type of weather yet... I am alone here. I need to think who can assist me." However, he did not mention what he meant by other available resources.

YCP1, on the other hand, demonstrates a more calculated approach and emphasises the importance of safety in their decision-making process: "Bad weather, ILS unserviceable and carrying no extra fuel are my considerations... I will not rush into diverting yet... I will put the emphasis on the safety of the crew, passengers and the aircraft." YCP1 also recognizes the importance of fulfilling his obligation to transport passengers safely: "The passengers are of priority in accordance with the company's obligation to take them to the destination too." Finally, YCP2 demonstrates self-awareness and a recognition of the importance of gaining more experience: "I am feeling anxious and stressed full about the situation... Hmm… I should gain more experience as I progress and will have a better picture."

Overall, the cadet pilots provided a range of responses reflecting their limited experience and training. Despite that, all the cadet pilots recognise the importance of safety, the need to

consider available resources, acknowledging their limited experience and the importance of self-professional development for their career.

All four officers, in general, mentioned the “complex situation involving challenging weather conditions”. While XSO1 and XSO2 express initial concerns about the weather, YSO1 and YSO2 prioritize safe landing as their main goal. Despite their different initial approaches, all officers share a common focus on safety as the most important aspect of the situation. XSO1 recognizes the weather as the main concern, stating "After reading the scenario, I can see the weather issues as the main concern. My goal is to land safely, but I have not come across this type of 'complex situation.' I need to recalculate the fuel now." Meanwhile, XSO2 feels pressured and acknowledges the “terrible” weather, saying "Goal is to land. A bit pressured. Weather is terrible."

YSO1's generic approach involves constantly re-evaluating the initial plan and considering the airline's fuel and operations policies. Similarly, YSO2 emphasizes monitoring fuel levels, holding when necessary, and considering non-standard missed approach procedures in the interest of safety. As YSO2 puts it, "all other aspects of the scenarios have zero prioritization as safety is the most important aspect."

While their individual approaches may differ, the second officers emphasized the importance of the safety of the mission. Their understanding of the scenario was slightly better than the cadets.

For the first officers’ group, XFO1, XFO2, YFO1, and YFO2 prioritized safety too while considering multiple factors such as weather, time pressure, and commercial issues in their decision-making process. As XFO1 puts it, they can't achieve everything, so they use all the resources available to them and always prioritize safety. Similarly, YFO1 emphasizes that safety is the top priority, followed by legality and then commercial considerations.

The majority of them emphasized the importance of gathering information and considering alternate plans. YFO2 stresses the importance of considering fuel and holding time when evaluating alternates, while XFO2 plans to try to get more information from ATC.

One difference is that XFO1 and XFO2 are more willing to consider missing Christmas plans and prioritize safety over commercial considerations, while YFO1 and YFO2 also prioritize safety but consider commercial considerations as well. As XFO1 says, "Always want to land safely," but he also plans to prepare for Plan B and gather more information should he decide to divert to the alternate airport. YFO2 acknowledges the un-forecast bad weather during the Christmas rush. It considers that, while commercially, the best option is to continue to the destination, they might not be able to land.

Another difference is that YFO1 and YFO2 are more thorough in their approach to decision-making and are calmer when expressing their views. As the narrative describes, they pay more attention to details and probe for more information. YFO1, for example, plans to evaluate reports from the destination airport and prepare for Plan B. YFO2 considers multiple options and evaluates alternates while continuing with the original plan.

Overall, all the first officers demonstrated a structured and methodical approach to decision-making, with safety being the top priority, and the importance of gathering information and considering alternate plans.

All four captains, with higher flying hours and more experience, clearly prioritized safety as the top consideration in their decision-making process, aligned with findings by Thomson et al (2004) and Drinkwater & Molesworth (2005). All of them tend to gather information from various resources, including ATC, weather radar, company policies, and dispatch updates, to make informed decisions. As stated by YCT1, "My first priority is the safety of the passengers and crew...I will do everything possible to ensure that we land safely." And as noted by XCT2, "Safety is my top priority, always. I will consider all options available and gather as much information as possible."

In addition to prioritizing safety and gathering information, all four captains also demonstrate a willingness to adapt their plans and consider alternate options if necessary. As stated by YCT2, "I will evaluate the chances of a successful landing at the destination with the given weather...If needed, I will use the captain's discretion to make the best decision." And according to XCT1, "We are prepared for this scenario (from past experiences), and we have multiple backup plans in case the weather gets worse."

Despite facing challenging circumstances, all four captains emphasised the need to stay calm, composed and confident, which is essential during critical situations. As stated by YCT1, "As the captain, I will try to remain calm and composed, and always look for solutions...I fully believe in my crew and our ability to handle this situation." And as noted by XCT2, "We have the experience, the skills, and the training to manage challenging situations like this. We will remain calm and focused and make the best decisions possible for the safety of our passengers and crew."

One difference is that XCT1 and XCT2 prioritize safety over commercial considerations, while YCT1 and YCT2 also consider commercial factors such as fuel availability and Flight Time Limitations. As stated by XCT1, "My priority is of course to land safely, either at destination or alternate...As long as I have sufficient fuel, can be managed." And according to XCT2, "My options will be bigger. Other issues not so important to me - my friend can wait to see me. Missing Christmas (an important family and friends celebration), this is not my first time." Another difference is that YCT1 and YCT2 are more thorough in their approach, evaluating various factors such as runway choices, parking space availability, and contamination affecting the destination. YCT1 mentioned, "I will find out if another choice of the runway is available...My utmost priority is safety." And YCT2 stated, "I will evaluate the chances of a successful landing at the destination with the given weather...If needed, I will use the captain's discretion to make the best decision."

In summary, while there are differences in the extent to which the captains consider commercial factors and the thoroughness of their evaluations, they all prioritize safety, gather information, adapt their plans if necessary, and maintain a calm and confident demeanour in challenging the situations Additionally, they all take a structured and methodical approach, considering alternate plans and not rushing into a decision. The differences lie in the extent to which they consider commercial factors and the thoroughness of their evaluations.

<u>Question 2:</u> Pilot's decision (Continue and Land, delay the approach or divert), decision-making process and if it is a safe decision. Any previous similar experience?

In this question, pilots were asked what their decision was after considering the multiple conflicting issues during the flight toward the destination and describing the decision-making process. We asked if their decision is safe or otherwise (with reference to definition of safety as described in section 2.3). Further, if they have experienced similar situations in their career and if that experience helps them in this scenario.

Their decisions vary between the different ranks. Again, safety was their ultimate aim at all times. Weather plays the dominant consideration followed by fuel requirements. Other aspects were least considered, and most did not even talk about the delayed arrival, curfew, appointment, or Christmas celebration. First officers and captains have experienced some of the situations played in the scenario.

Cadet pilots were unsure but tend to make very quick decisions, and as the rank increases, pilots took more time and considered more aspects before arriving at a decision. The discussion among the cadet pilots in Airline X revolves around their decision-making skills during flight operations. XCP1 quickly decided to divert to the nearest airport due to bad weather conditions, stating, "I think the weather is really bad. I will divert to the nearest airport which I just flew over. I think this is the safest thing to do. But I need to explain to my instructor later."

However, XCP2 revealed that their training program did not cover diversions, saying, "Actually, I have never done a diversion, but I think to be safe, I better do that. I have almost a full tank. We fill up full for all our sorties every time. During training, this has not been discussed or taught to us. Always at the circuit area or training area."

YCP1 highlighted the importance of considering various aspects before arriving at a decision, saying, "As expected, my sources of information are the ATC, weather reports, and the company. I think I will hold, and that maybe is a safe decision. It is a safe decision as I considered the Swiss Cheese Model. Low fuel could be an issue, and in order to avoid possible fuel emergencies, I have to act fast."

On the other hand, YCP2 decided to hold and delay, stating, "I will hold and delay because unsure of the extent of the weather. Yes, I believe it's a safe decision." This highlights a difference in decision-making among the cadet pilots, as YCP2 chose to wait and gather more information before arriving at a decision.

The second officers in both airlines considered a few aspects to make decisions in challenging situations for them. XSO1 was initially unsure of what to do but acknowledged the need to make the safest decision. XSO1 said, "My decision will be to divert but to tell the truth, I am not very sure. I've heard my friends have done diversion but that was due to fuel. They were asked to hold as there were many arrivals. I am not sure how much fuel I have. Maybe, I should wait for a while. Difficult to decide. There are a few other things also I need to consider. But I will try to make the safest decision."

Meanwhile, XSO2 was willing to leave the decision to the captain. He said, "I will leave it to the captain. He will decide". In his opinion, the captain will make better and safer decisions.

YSO1, taking a more proactive approach; said, "I will probe the ATC for more specifics for the situation at the airport such as if any other aircrafts have successfully landed, current weather observations and the company policies regarding tailwinds for landing. Yes, I think that is a safe decision."

YSO2, who seems to have a more calculated approach, shared his strategy, saying, "My planning would have started at the top of the descent point, especially in the evaluation of the alternates and probe ATC for more information pertaining to the weather, the success of approach by other aircraft and always be prepared to go-around and divert."

It seems that the second officers are still doubtful of their decisions and are sometimes inconsistent. Nonetheless, there are similarities between the first officers' views, as they both value safety and the importance of considering multiple factors before deciding their course of action.

The First Officers emphasized the importance of gathering information before deciding. They highlighted the need to consider weather conditions, co-pilot limits, fuel requirements, and runway conditions. XFO1 mentioned the importance of discussing the situation with the captain and considering holding if necessary. XFO2 drew on their previous experience in similar situations and emphasized that safety is paramount. YFO1 and YFO2 both highlighted the importance of using all available resources, such as ATC, weather reports, and information from the company, to arrive at the safest decision.

XFO1: "Definitely I will ensure my decision is the safest. I don't have a concrete decision for now, but I need to gather more information. For more details on the weather, I will get more updates, listen out, and will talk to my captain. We may have to hold on to make the best/safest decision. So, for now, I need to buy some time. If the weather goes pass the FO limit (the wind and visibility), the captain has to take over the landing."

YFO2: "I will use all resources available to me at that time such as the ATC, company, other aircrafts, weather trend forecast and the actual weather reports in order to arrive at the safest decision".

The Senior First Officers statements demonstrated a structured approach to decision-making (thorough and disciplined), drawing on their experience and knowledge to gather information and make informed decisions, one that is essential in the aviation industry

particularly for pilots in leadership positions. They emphasised the importance of teamwork and communication, especially in identifying and mitigating potential risks. By using all available resources and working as a team, pilots can reduce the risk of accidents and ensure the safety of everyone on board.

XFO2: "I have had some similar situations. We ended up landing. The weather was not so bad actually. I will discuss this with my team and update the weather. ATC can be a good and quick resource. I will look at the co-pilot limits in the policy and fuel requirements for diversion. It may be more challenging if it's at night. I need to consider runway conditions. Others like curfew, friend and celebration do not matter much at this time. I will keep the option open. Safety is paramount at all times".

YFO1: "The resources that I gather will also be used for my Plan B consideration. I will also engage the company to help me gather more information. Plan B is a safer decision and as I am paid to make a safe decision."

The replies by the captains centred around the topic of decision-making in challenging situations during a flight, the importance of safety and using all available resources to make informed decisions. Captain XCT1 humorously stated, "If it scared the shit out of me, I would press the TOGA and go. I will ensure I have enough fuel, but I will try the approach. I may consider other runways and get updates from ATC. I am sure the ATC understands our situation. Maybe can negotiate the curfew time.". He was very sure of his plans to continue that approach and abort the approach if required with backup plans.

Captain XCT2 however, took a more cautious approach from his past experiences, stating, "Lesson I learned over the years, don't bust any policy. I will continue the approach with GA options always available. Stabilised criteria must be ensured. If need to just go around. Will consider all resources … ATC, other aircrafts nearby and may call the company to update due the curfew)". He mentioned the importance of planning early to avoid surprises.

The captain in Airline Y, YCT1 emphasized the importance of safety and using all available resources and ensure a safe decision based on his past experience in a similar situation. He said, "If the odds are stacked against me, I will consider a diversion. I will be using all available resources such as the ATC, weather radar, preceding aircraft encounters or even negotiating an extension of the curfew with the ATC. Nevertheless, diverting will be a safe decision. I have encountered similar situations that had been challenging even though not identical."

The other captain, with an almost similar response, YCT2 considered the weather conditions and flight time limitations, stating, "I will consider the chances of a successful landing at the destination with the given weather. I will ensure that no rules are broken in the process. I will engage the ATC, company and seek information from other aircraft in the vicinity."

All pilots agreed to use ATC, weather reports, and the company as sources of information. YCT1 added, "I would communicate with other aircrafts in the vicinity for other pertinent information." YCT2 also used Flight Time Limitations to help with decision-making.

The conversation highlighted the importance of clear communication and adherence to policies and regulations in ensuring a safe decision, particularly in challenging situations.

<u>Question 3:</u> At the end of section B of the questionnaire, we sought feedback of the scenario and any additional points that the pilots would like to highlight. Almost all the pilots mentioned that the scenarios were good and this "complex" situation although have not happened (and they wish it will never happen to them) was good training for them.

The response from the cadets and second officers was positive, with most of them acknowledging the importance of such scenarios in their training. One cadet, YCP1, shared his experience during flight school, where he had faced a similar predicament but chose to avoid it. Nevertheless, he found the scenario helpful in gaining insights into the real world of flying.

The first officers also found the scenario useful in their discussions, with XFO2 expressing gratitude for the opportunity to discuss such points. YFO1 noted that the scenario encouraged open communication and was crew resource management oriented, giving any operator confidence in safety-related matters.

The captains also found the scenario helpful, with XCT1 stating that it would be useful for his training, and XCT2 emphasizing the importance of knowing what was important for safety when dealing with multiple conflicting objectives. YCT2 shared his own experience of landing in unfavourable weather conditions. It noted that the scenario would have aided him more if it had been presented earlier in his command years.

While most participants found the scenario helpful in their discussions, some had already faced similar career situations. YSO2, for example, had experienced a similar scenario but had the luxury of time to anticipate it and had successful landings at the destination in most cases. YCT2 had also landed in unfavourable weather conditions but had already gained experience in such situations.

Overall, the participants agreed that the scenario provided a valuable learning experience, whether they had faced similar situations before or not. It highlighted the importance of communication, crew resource management, and prioritizing safety in decision-making. The captains agreed that this is a good scenario for training purposes.

General: Risk and Safety

Four general open-ended questions (with few sub-questions) were asked to the four pilot group participants. The questions were regarding their understanding of risk and safety, pilots' own assessment of their risk tolerance level and its variability as they progress in their rank, pilots understanding of the airline policies regarding safety and risk and finally, their general feedback on the questions and any other additional comments. This section reports the interview results from them.

<u>Question 1:</u> Definition of risk and safety, relationship and examples

As the cadets pondered over the question of risk and safety (against the definition in section 2.3), they struggled to define and differentiate the two concepts. XCP1 noted that "both terms are related and complement each other." At the same time, XCP2 mentioned that "it's difficult to draw a line between risk and safety." YCP1 added, "They are co-dependent factors as they exist because humans don't tend to follow safety guidelines unless there is an existence of risk, to avoid the risk."

The cadets also discussed the importance of risk in decision-making. YCP2 noted that "risk influences decision-making," while XCP1 described the risk as "consequences of outcome on decision making." YCP1 added, "A risk is an event that can turn into a hazard when we breach safety lines that have been laid down to prevent accidents and mishaps."

While they agree that risk and safety are closely related, the cadets acknowledged that there are important differences between the two. XCP2 stated, "I guess that risk is the appetite towards action or decision potentially leading to dangerous repercussions," while YCP2 offered the definition that "risk is something that you cannot foresee. It can be considered a danger to safety."

The cadets also shared examples of risk and safety in various contexts. XCP1 identified human factors, the environment, and technical issues as examples of risk, while YCP1 cited engine failures, navigation errors, and track errors. YCP2 mentioned refuelling errors and engineering errors as risk examples, which are often related to human factors. Regarding safety, XCP2 noted that "safety is about no injuries or accidents," while YCP1 described it as "securing oneself from any form of injury or harm."

Overall, the cadets' discussion highlighted the importance of carefully managing risk and safety in any endeavour. As YCP1 stated, "By following safety guidelines and taking appropriate

steps to mitigate risk, individuals and organizations can avoid potential hazards and achieve their objectives safely and effectively."

To a certain extent, all the cadets, when initially listening to the question, paused for a while trying to think and define risk and safety. They also had some difficulties to provide suitable examples especially differentiating examples of risk and safety. They admit that it's a simple word used almost constantly but never thought about it until this question was posted to them.

Similarly, we when asked the second officer, they too paused, and a few started smiling and looking confused. When asked to define risk and safety, the second officers' responses indicated a general understanding of the concepts, but with some variation in their definitions and understanding of the relationship between them. This could be influenced by their limited experience as pilots and due to the limited emphasis given to them during the initial flight and theoretical training such as CRM.

XSO1 defined risk as something that endangered life, health, or well-being and gave examples such as mother nature events and malfunctions in operations. They also suggested that risk and safety are related: "the higher the risk, the lesser the safety. If we drive fast, higher chances of an accident." XSO2 also agreed that risk and safety are related, stating that "more risk means it impacts safety. Am I right? ha ha ha."

YSO1 defined risk as something that has the potential to disrupt and cause an undesirable situation and gave examples such as calculated risk and risky behaviours. They suggested that one should not display risk-taking behaviour unless it is a calculated or measured risk. YSO1 also suggested that risk and safety are inversely proportional, meaning that "the more risk, the lower the safety." YSO2 similarly suggested that safety and risk are inversely proportionate, stating that "the more risk one takes, the more likely it is for an incident to occur."

XSO1 and YSO1 seemed to emphasise the importance of calculating or meas. At the same time, XSO2 and YSO2 focused more on the relationship between risk and safety. YSO2

provided specific examples of risks encountered in their work, such as take-off and landing phases of flight, flying over remote regions, and flying through hostile regions. In contrast, the. In contrast, the other second officers gave more general examples of risk.

Overall, the second officers had some difficulty defining the words and providing examples. They were unsure of their answers and sometimes could not differentiate between the what's risk and safety. Even though there were some variations in their definitions and understanding of the relationship between risk and safety, all second officers seemed to agree that the two concepts are related and that increasing risk generally decreases safety, and vice versa.

When asked about their understanding of risk and safety, the first officers had varying opinions too. Two of them struggled to provide clear definitions and examples for the terms "risk" and "safety" while others had more confident answers. XFO1 defined risk as an "evaluation of how dangerous the situation is", and stated that "all flights have risk", while safety "is about managing the different risks involved." XFO2 described the risk as "something that has the potential to disturb or cause an undesired state" and stated that safety is "protecting of self and property."

On the other hand, YFO1 defined risk as "any factor that reduces safety" and explained that they mitigate risks through good preparation and awareness of the Swiss Cheese theory. They also acknowledged that pilots (due to human factors issues such as fatigue) contribute to the risks too. When asked about safety, YFO1 said it is "about keeping harm away from people and equipment," and added that "safety and risk are related as risk lowers safety."

YFO2 described risk as "how far we can take something until it becomes unsafe," citing examples like passengers, refuelling, weather, ground equipment, and other aircraft. He also explained how he mitigate these risks by assessing each element. When asked about safety, YFO2 said it is "not to hurt or damage, to keep people or property away from harm's way," and added that "safety and risk are inversely proportionate."

Interestingly, both XFO1 and YFO1 mentioned managing risks and being aware of potential risks. Meanwhile, XFO2 and YFO2 emphasised the potential negative consequences of risk and how it relates to safety. Despite their initial difficulty defining the terms, all four first officers agree on the importance of understanding and managing risk to ensure the safety of everyone involved.

All four captains emphasize the importance of safety and its relation to risk. They all agree that there is no such thing as a perfect flight, and that errors and mistakes can happen. Set procedures and rules have limitation and may not be able to trap the errors and mistakes. All four also recognized that threats can come from various sources such as weather, ATC, aircraft status, and cultural differences among crew members. They all agree that safety is about achieving a successful outcome without injury or incident as they would have been avoided, trapped, or mitigated with their vast experience.

For the captains, XCT1 states, "Safety is the chance of not being able to have a successful or safe outcome in a mission. Terms are Threat and Error Management (TEM) and Crew Resource Management (CRM)." XCT2 expands on this, saying, "Risk is closely tied to threat. For example, ATC can be a threat due to vectoring. High grounds are risk which can cause CFIT."

YCT1 provides a different perspective, stating that "Risk is a variable that measures the rate of success or failure of a certain scenario. Types of risk could be bad weather, aircraft status, ATC, other aircrafts, area environment, airport facilities, political instabilities/geopolitics, commercial pressure, cultural differences of crew members, SOP changes that are taken lightly, conflicting memories of previous/outdated procedures and health impact due to the job." YCT2 agrees, adding that "Risks are threats related to decisions one makes. I had a serious incident of a bird strike one day and another of a cargo pallet shifting during a flight. Other types of risks are related to destination weather, season and political situations...The increased risk reduces safety and vice versa."

While all four captains share similar views on the importance of safety and its relationship to risk, they differ in their specific focus and language used to discuss these concepts. XCT1 and XCT2 mention Crew Resource Management (CRM) and Threat and Error Management (TEM) as important concepts related to safety. These strategies focus on improving communication, decision-making, and situational awareness in the cockpit to reduce errors and prevent accidents. They also discuss how risk can impact safety, with XCT2 specifically mentioning the potential risks associated with vectoring from air traffic control and high terrain.

In contrast, YCT1 and YCT2 focus more on the various types of risks that can impact a flight, including bad weather, aircraft malfunctions, and political instability. They also emphasize the importance of having a serviceable aircraft, sufficient fuel, and tailored procedures in place to prevent incidents. YCT2 provides specific examples of incidents, such as a bird strike and cargo pallet shifting, and emphasizes how crew decisions can impact risk and safety.

Overall, the captains from both airlines share similar views on the importance of safety and its relationship to risk.

<u>Question 2:</u> Pilots personal risk rating (1-10 where 1 is lowest risk and 10 being highest risk) and if their risk perception and tolerance changed as they progress along their career.

A "personal risk rating" is a subjective assessment or evaluation that an individual makes regarding the level of risk associated with a particular situation, decision, or action. It involves considering various factors and circumstances and then assigning a level of risk based on one's perception and judgment. Personal risk ratings can vary from person to person, as different individuals may have different perceptions of risk based on their unique backgrounds and perspectives. The risk rating used in this question was based on Hunter's (2006) work and using the Likert Scale of 1 to 10 where 1 is lowest risk and 10 being highest risk. This was explained to the pilots prior to asking them of their own rating.

Table 4.2:

Personal risk rating, risk perception and risk tolerance of pilots at different ranks

		CP1	**CP2**	**SO1**	**SO2**	**FO1**	**FO2**	**CT1**	**CT2**
Airline X	Risk Rating	7-8	6	6	5-7	3	3	2	2
	Risk Perception	Increase	Improve	Increase	Increase	Increase	Increase	Increase	Increase
	Risk Tolerance	Unsure	Increase	Reduce	Increase	Neutral	Reduce	Reduce	Reduce
Airline Y	Risk Rating	8-9	3	8	5	3	5-6	2	2
	Risk Perception	Increase	Increase	Increase	Increase	Increase	Increase	Increase	Increase
	Risk Tolerance	Increase	Reduce	Increase	Neutral	Reduce	Neutral	Reduce	Reduce

The data in table 4.2 indicates that there is a tendency for personal Risk Rating to decrease as pilots progress in their careers and gain more experience in terms of years and total hours flown. Inexperienced pilots, such as cadets and second officers, generally recorded higher Risk Ratings compared to their more experienced counterparts, such as First Officers and Captains. This suggests that the more experienced pilots have developed better risk management skills, allowing them to mitigate potential risks and reduce their overall risk levels effectively.

However, the junior pilots showed an increase in Risk Perception, indicating that they were more aware of potential risks earlier in their careers. This risk awareness is a linear progression with experience and rank, as the more experienced pilots demonstrated a significantly increased perception of risk. This could be attributed to the fact that junior pilots may be more cautious and conservative due to their lack of experience. In contrast, the more experienced pilots may have developed a better understanding of the risks involved and are able to assess them accurately.

Finally, the data revealed a general trend of decreasing Risk Tolerance among First Officers and Captains, while some cadets and Second Officers were uncertain about their tolerances. Overall, as the rank (and experience) increase were associated with a decrease in Risk Tolerance. This could be due to the fact that as pilots gain more experience, they may become more risk-averse and less willing to take unnecessary risks. However, it is important to note that some pilots may have a higher Risk Tolerance than others, regardless of their experience or rank.

In conclusion, the data suggest that there is a correlation between experience, rank, Risk Rating, Risk Perception, and Risk Tolerance among pilots.

<u>Question 3:</u> Pilots' awareness of company policies (operational limitations, fuel & contingency planning, safety and risk, TEM & CRM) and how it influences/assists in decision-making (risk perception and risk tolerances).

The question focuses on pilots' awareness of company policies related to operational limitations, fuel and contingency planning, safety and risk, Threat and Error Management (TEM), and Crew Resource Management (CRM). The aim is to explore if this awareness influences and assists pilots in their decision-making process, particularly in relation to their risk perception and risk tolerance as employed by Hunter (2002) and Orasanu et al (2002) in their research. The question also aims to evaluate if the pilots understanding of the company policies and procedures, provides them with knowledge to assist them in making informed decisions and effectively manage risks while flying. Based on our own experiences, this knowledge is required and essential for decision-making, considering how it has proven beneficial in our own past experiences.

XCP1 said, "I am aware there are policies and rules. We have attended the CRM, TEM courses and attended safety briefings. It helps in decision making, using the checklist, procedures and crosschecking to guard me." This statement shows that XCP1 has understanding of company policies. XCP2, on the other hand, stated, "Aware of policies but we don't have specific

manuals. I have not attended any CRM/TEM courses yet." XCP2 acknowledges that there are policies in place but has not undergone any training on CRM or TEM courses. This could be a concern as it may affect his risk perception and decision-making process.

YCP1 reported, "There are organizational risk policies that I am aware of. During my flying school, there was a strong emphasis on airmanship, especially during startup, taxi, and basic aerodrome rules. We are also taught how to interact with crew from various backgrounds and cultures." YCP1 recognizes the importance of being aware of the company's policies and that they received training on airmanship during flying school, which could help them make informed decisions during flights. Similarly, YCP2 emphasized the importance of airmanship and safety during the course. "We are taught airmanship since the beginning of the course. On top of that, other aspects of safety in the aircraft and the apron are emphasized. CRM is often mentioned, and we undergo a basic course in this. It helps us interact and communicate among the instructors and with other fellow trainees when we begin to do joint navigation exercises." This shows that YCP2 was trained on the basics of CRM, which could assist in communication among crew members during flights.

Overall, all the cadets are aware of the policies, and most of them have undergone training on CRM and TEM courses. There is a strong emphasis on airmanship during training. The policies are perceived to be practical and useful in the job.

The second officers responded with varying levels of experience and exposure regarding their awareness of company policies. XSO1 recalls attending a compressed Crew Resource Management (CRM) course and receiving safety bulletins from time to time but feels that many of the discussions in the course were beyond his current level of experience: "Most discussions at the course, I don't quite understand as I don't have experience," he explained. On the other hand, XSO2 relies heavily on the manuals when unsure about procedures and finds the company's policies helpful for inexperienced pilots like himself: "If unsure or 50/50 I refer to the manuals. Good for an inexperienced pilot like me," he said.

In contrast, the young second officers in airline Y (YSO1 and YSO2) in the study appear to have a more robust understanding of the company's policies and their implications for risk perception, risk tolerance, and decision-making. YSO1 credits CRM and Threat and Error Management (TEM) training with helping him adapt to multi-crew settings and handle routine flight duties: "CRM/TEM has helped me considerably in adapting to multi-crew settings. The operational policies help me to tackle problems that I encounter in my routine flight duties," he said. YSO2, on the other hand, cites regular safety reports, communications, and refresher courses as sources of information that help him stay up to date on the company's risk and safety policies: "I am aware of the risk/safety policies in the company... The annual CRM refresher courses help too... the information provided is sufficient especially when comparing to his previous company that didn't have such documents," he explained.

It appears that while all the second officers in our study are aware of the company's policies to some extent, the second officers in airline Y, (YSO1 and YSO2) had more comprehensive exposure to these policies, which in turn helped them make more informed decisions and manage risks effectively while flying. On the other hand, airline X second officers, (XSO1 and XSO2) seem to have a more limited understanding of the policies, relying on bulletins or manuals to guide their decision-making.

All the first officers actively shared their perspectives about their knowledge and familiarity of the company policies and their approach to risk tolerance and decision making. FO1 specifically emphasized the importance of limitations sections in the policies and checklists, as they reduce ambiguity and make decision-making easier. However, they also acknowledged that although policies are important, experience plays a crucial role in their decision-making process. FO1 said, "CRM/TEM helps in the thought process, but the experience is more important." FO2 mentioned the various safety reports, bulletins, and incidents shared by the company. They also found CRM/TEM useful but believed learning from other crew members

and online resources was more beneficial. FO2 stated, "Talking to another crew and learning online [is] more useful, I think."

YFO1 shared his confidence in the company's CRM-oriented culture and flat power gradient, encouraging an open flight deck concept. He believed the existing policies give the pilots the necessary confidence in safety-related aspects. However, YFO1 also recognized the importance of experience in assessing and managing risks, saying, "Experience is a huge factor and the perception of risk changes accordingly." YFO2 spoke about the company's Safety Management Systems (SMS) and various manuals, including the FCOM and FCTM, which guide his decision-making process. He also highlighted the importance of past experiences and joint CRM sessions with the cabin crew in shaping their understanding of safety aspects. YFO2 said, "The CRM refreshers and the joint CRM sessions with the cabin crew contribute a lot to me as I am able to relate to safety aspects from the cabin crew's point of view as well."

Overall, the four first officers acknowledged the importance of company policies, safety manuals, and CRM/TEM in their risk perception, risk tolerance and decision-making process. However, they also emphasized the critical role of experience and continuous learning in assessing and managing risks effectively.

The captains generally were very broad-minded and shared their overall perspective and thoughts on company policies, risk tolerance, and decision-making. XCT1 acknowledged the importance of policies as guidance, but also stressed the need to improvise and modify if required, placing safety as a higher priority than policies. He highlighted the significance of experience and continuous practice to ensure safety by saying, "Policies are just guidance - safety is more important than policies. I need to improvise/modify if required. CRM and TEM are important but not as a procedure. Important is the practice to be safe."

XCT2 expressed confidence in following policies and procedures, such as the stabilised approach criteria. He believed that management put a lot of thought into these policies, which gave them faith and confidence to follow. However, he pointed out that pilots must always stay

updated with new changes, as not all pilots may read the disseminated information. XCT2 said, "It gives me faith and makes me confident to follow. CRM/TEM forces a pilot to use the tools provided and assist in considerations. But pilots must always read what's new or the changes even though the management disseminates, not all pilots read."

YCT1 and YCT2 acknowledged the numerous safety and risk policies in place, such as CRM and TEM training, automation usage, and SOPs. They believed that these policies helped mitigate risks effectively. YCT1 stated, "Examples are the usage of automation, strong knowledge of SOPs and type of approach selection helps mitigate the risks." YCT2 mentioned their airline's reporting culture, which encourages pilots to report incidents without fear of punishment. They also highlighted the open-door policy of the safety department and the resumption of CRM courses in recent times. YCT2 said, "The airline encourages a reporting culture. As such, a robust safety reporting system is in place with a so-called non-punitive policy. Nowadays, the CRM refresher courses are an annual event."

Overall, the four airline captains shared their company's focus on safety policies, procedures, and training. They emphasized the importance of balancing policies and experience in making effective decisions and prioritizing safety. They also highlighted the significance of continuous learning and staying up to date with new policies and changes.

<u>Question 4:</u> Pilots afterthoughts regarding the scenario and any other feedback.

The purpose of for final question was to determine if the pilots' perception of risk and their tolerance changed after answering the questions in Sections B & C and receiving any other additional feedback. Most pilots found the questions in both sections interesting and relevant to their piloting experiences. While cadet pilots and second officers were still unable to fully understand the scenario, they reconsidered their decisions. On the other hand, first officers and captains were more involved in answering the questions and providing additional feedback (and

some suggestions). Still, their overall perspective was that their decisions would remain unchanged.

While some cadet pilots had not experienced such a situation, they acknowledged the possibility and the need to be alert. XCP1 stated, "What's been discussed based on the questions has actually made me more alert of the possibilities. I will take note and remember." XCP2 appreciated the questions and mentioned, "Never thought of. Simple but difficult. Not much experience but I will be careful if it happens."

YCP1 found the scenario challenging and confessed to not having given much thought to such a situation at his stage of his career. However, he remained confident in his earlier decision, stating, "I am still inclined to stand by my decision that I stated earlier." YCP2 acknowledged that the scenario could be encountered in the future and found the questions posed practical and normal for a pilot to undergo, commenting, "This scenario is clear. I may even encounter such a situation someday."

Overall, the cadet pilots appreciated the opportunity to reflect on their decision-making processes and the risks involved. They recognized the importance of being alert and prepared for any challenging situation they may encounter in their careers as pilots.

The second officers also very appreciative and interested to share their thoughts on the interview session. XSO1 found the session useful and said, "these sessions are really useful. I am not sure if I will do it differently but definitely made me think". On the other hand, XSO2 found the discussion interesting and said, "Not been discussed before but definitely very useful. Makes me alert. I will consider more aspects. My decision may change. Thank you for the discussion".

YSO1 emphasized the importance of experience in decision-making. It said, "It's important to see the big picture in this situation. I think my decision and the decision-making process will change as I gather more experience". YSO2 acknowledged the remote possibility of such an occurrence. It said, "Very remote chance of all the elements coming together, however, it

is still possible, but the decision would be best decided on that day. My consideration may be little difference after this".

Thus, it is evident that the second officers also found the scenario to be thought-provoking and useful in improving their decision-making skills.

The first officers had varying feedback and responses to the scenario and general questions on safety and risk presented to them. XFO1 acknowledged the situation's complexity, stating that "too many variables" were involved. However, he emphasised that safety should always be the main consideration and that he now had a better understanding of the importance of risk assessment. XFO2 also found the discussion useful, stating that it helped him explore conflicting issues and better understand safety and risk. He acknowledged that he had not received formal training on risk assessment but still believed that he considered most parameters in deciding.

YFO1 thought the scenario was thought-provoking and made him to consider the possibilities of a routine flight turning out to be complicated. However, they ultimately decided to stick with this earlier decision. YFO2 had experienced a similar predicament in the past, which made his decision-making process slightly easier. They saw no need to change their decision-making process and assessments.

Despite their differing opinions, all the first officers agreed that such scenarios should be discussed more often. As XSO1 pointed out, "these sessions are really useful," and XSO2 stated that the discussion was "really interesting" and that it had made them more alert. YSO1 emphasized the importance of seeing the big picture in such situations. At the same time, YSO2 acknowledged the remote chance of all elements coming together but also stressed the need to decide based on the specific circumstances of the day.

The four captains discussed the scenario presented to them energetically and shared their feedback and few genuine pieces of advises from their years of experiences. Captain XCT1, expressed concern about using too many acronyms in safety, saying "In safety there should not

be too many acronyms. Every Human Factors and CRM class sometimes introduces new ones... not good especially for the cadets or second officers." However, he acknowledged the importance of the discussion and noted that it would benefit pilots training on risk, safety and decision making.

Captain XCT2 shared his thoughts on the scenario and emphasised the importance of following company policies and procedures, stating "Continue the approach and always have the GA option. Ensure stabilized criteria. If need just to go around… Good questions to probe thinking and make, consider/reflect company policies and definitions."

Captain YCT1 found the scenario and the questions thought-provoking and believed that it would be beneficial for junior pilots, stating "A reasonable scenario even though it's not realistic. However, it highlights the worst-case scenario of what we as pilots may have to face sometimes. The junior pilots would definitely find this thought-provoking." Finally, YCT2 saw the scenario as a good learning tool for inexperienced pilots, saying, "A good scenario to help the inexperienced pilots think and could be a good learning tool trying to find solutions while applying all the skills, knowledge and policies learned all these years." Overall, the captains captain found value in the scenario discussion, with Captain XCT1 noting that it was good to talk about risk and safety using a scenario and have discussion during CRM or TEM courses especially with junior pilots.

Discussion

Introduction

Risk perception and risk tolerance are crucial factors influencing pilots' decision-making and the safety of flight operations. Previous research, as highlighted in the literature section, supports the significance of these constructs. However, existing studies have been limited in scope, typically focusing on specific groups of pilots or specific stages of their careers within particular aviation organizations. To address this gap, our research interviewed 16 pilots from two large international airlines, with eight pilots from each airline, representing four different rank groups. The objectives of our research were threefold: 1. To explore pilots' understanding of risk and safety at different stages of their ranks, 2. To investigate the pilots' risk perception and risk tolerance in given scenarios, and 3. To compare and contrast risk perception and risk tolerance between pilots from the two airlines. Our research employed three sets of questions, encompassing pilot demographic information, scenario-based risk perception and tolerance inquiries, and general questions regarding risk and safety. To focus the research, we limited the boundaries to three areas: environmental factors, aircraft technical status, and personal conditions. The subsequent discussion is organized according to the research objectives outlined in this study. Certain aspects of the discussion were also already incorporated in the results section.

Based on the research findings, it is evident that the initial categorization of pilots into four groups can be simplified into two distinct categories: novices and experts. This simplification aligns with previous studies conducted by Landry (2006); Rowe & Wright (2001), and Thomson et al. (2004). The novices, which include cadet pilots and second officers, have less experience and confidence compared to the experts (first officers and captains), who have accumulated extensive flying experience over a longer period of time. The expert group tends to consist of older and more mature individuals. Novices are pilots undergoing training and their exposure to adverse weather conditions, technical failures and commercial pressures are minimal

compared to experts who are exposed to those stated elements with bigger picture of the overall operations. Hence, the terms "novices" and "experts" were used in specific sections of the discussion to differentiate between these pilot groups.

Pilots' understanding of Risk and Safety

In the aviation industry, in particular flight operations, risk and safety are intricately linked (they are closely connected and often coexist) and it is important for the pilots to have a clear understanding of these fundamental terms. This understanding allows pilots to grasp concepts such as risk perspective, risk tolerance, and decision making, which are essential for maintaining a high level of safety. By comprehending risk and safety, pilots can make informed decisions, comply with regulations, promote effective communication, and drive continuous improvement within the industry. Ultimately, this knowledge is a fundamental requirement for pilots to ensure the safety of flights and safeguard the well-being of all individuals involved in aviation operations. As in the case of the scenario provided, a good understanding of these terms will heighten their awareness regarding the significance of risk and safety, enabling them to recognize potential risks and effectively manage them when making decisions to ensure a safe outcome.

The interviews conducted with pilots shed light on a significant challenge they faced in accurately defining and differentiating the terms "risk" and "safety." Despite these words being commonly used in flight operations, briefings, and debriefings, pilots struggled to provide precise definitions. Their responses revealed a general understanding of the concepts, but when prompted to articulate clear distinctions, they encountered difficulties. It was interesting to observe that pilots often smiled while reflecting on the definitions, indicating a level of introspection and realization of the complexity involved.

While pilots recognized the intricate relationship between risk and safety in decision-making processes, their understanding, particularly regarding risk, was not entirely precise. Many pilots found it challenging to draw a clear boundary between the two terms, while others

admitted that they had not deeply contemplated the distinction until prompted during the interviews. When discussing safety, pilots tended to associate it solely with danger, harm, and negative consequences, without providing specific examples. Furthermore, it was observed that pilots from different ranks and airlines often blurred the definitions of risk and safety. However, as the rank of the pilots increased, there was a greater level of confidence in providing definitions, even if they were incorrect. Nonetheless, all pilots emphasized the utmost importance of both risk and safety in their daily operations. This represents their rational view of operationalisation of the terms.

Our research revealed a noteworthy observation: none of the 16 interviewed pilots, regardless of their experience levels, were not able to describe "risk" according to the technical definition as stated in the ICAO SMS (Annex 19) document (Risk = probability x severity). Instead, their examples primarily focused on identifying potential hazards, such as weather, terrain, human factors, and culture, without considering the crucial elements of probability and severity. This finding underscores the importance of clarifying and promoting a proper understanding of risk among aviation practitioners, particularly pilots.

Risk assessment involves multiplying the probability of an issue occurring by the severity of its potential consequences. Consider the scenario during the Christmas season, associated with winter and thunderstorms, where there's a possibility of encountering icing conditions. If during the preflight weather check there is no indication of icing, hence the probability of icing is relatively low, but the severity is high as icing can significantly affect the aircrafts performance and safety, during landing. It is essential for pilots to possess a solid grasp of risk's fundamental definition in order to effectively manage and mitigate potential risks in flight operations.

Undertaking this MSc program and conducting further research has revealed the potential knowledge gap regarding risk and safety among professionals in the aviation field. It became evident that without this investigation, we too would have struggled to accurately define risk. Surprisingly, our review of existing literature and industry materials yielded no specific studies,

documents, manuals, or policies that delved into the definition and understanding of risk from the perspective of pilots or other aviation practitioners. Furthermore, we found that CRM and (Crew Resource Management) and other safety programs conducted in both airlines did not emphasize the importance of defining and understanding risk.

However, we did observe that pilots from airline Y recognized and discussed the significance of considering risk in their daily operations to enhance safety. These observations and findings highlight the need for a more comprehensive exploration of how practitioners, including pilots, perceive and define risk. Gaining insights into their perspectives will enable the development of more effective risk management strategies and the enhancement of safety measures within the aviation industry, particularly for pilots.

While the pilots struggled to provide an accurate definition of "risk," they demonstrated a strong understanding and emphasis on safety. Safety emerged as the pilots' utmost priority and acted as a guiding principle in their decision-making, showcasing their unwavering dedication to ensuring a secure operating environment. For them safety is similar or even overweighs risk.

The pilots' recognition of safety as a fundamental principle underscored its critical role in their work. It influenced their actions and choices, guiding them to minimize risks and prioritize the well-being of all individuals involved. While arriving at a precise definition of risk may have presented difficulties, the dedication of the pilots participating in this study was evident in their commitment to upholding industry and their airline standards and fostering a safety-oriented culture within their respective airlines.

Risk perception and risk tolerance of pilots at different ranks

To address this objective, we employed specific questions focused on risk perception and risk tolerance. Additionally, we analysed the pilots' responses and decisions made in response to the presented scenarios. By incorporating these approaches, we aimed to gather insights into pilots' risk perception and tolerance levels across different ranks.

Previous research and theories have consistently indicated that as pilots gain more experience, their risk perception tends to increase while their risk tolerance decreases. Our research findings align with this pattern, as demonstrated in Table 4.2. The data clearly illustrates that as pilots' rank increases, which typically corresponds to higher flying hours, they exhibit more cautious decision-making, optimising risk while prioritizing safety aspects. Personal risk rating (scored from 1 to 10) was seen decreasing as pilots progress through their careers. Cadet pilots tend to take higher risks and it sharply reduces for the captains, that is pilots tend to take less risk as their rank increases. Similarly, as their risk perception increases, the risk tolerance reduces. This trend was observed for both airlines. This suggests that the more experienced pilots have developed better risk management skills through their improved perception of the situations which allows them to mitigate the potential risk and able to reduce the overall risk effectively.

The observations and comments from the pilots during the approach and landing scenario further support our findings. Novice pilots, including cadets and second officers from both airlines, struggled to fully comprehend the scenario's conflicting conditions and requirements. While their priority was always safety, their perception of the risk involved was limited. They primarily expressed concerns about the weather conditions, citing their limited experience in encountering such adverse situations. Additionally, they occasionally considered fuel requirements as a priority. In contrast, the expert pilots, consisting of first officers and captains, demonstrated a better understanding and comprehension of the situation. They were able to prioritize using risk assessment and management approach (as described in section 2.4), based on a more structured risk evaluation approach, considering various factors such as weather, time pressure, commercial considerations, and potential assistance from air traffic control. This finding aligns with the research conducted by Thomson et al. (2004) on helicopter pilots, indicating that experts' perception of relative risk is more accurate due to their extensive flying hours and exposure to different destinations worldwide.

Reflecting on our own experiences, we can relate to this pattern. In the early stages of our careers, our limited experience would have restricted our perspective and understanding of such scenarios. However, as we progressed and gained exposure to different destinations and encountered various challenges, our perception would have become broader. Similarly, pilots from Airline Y exhibited a better approach to assessing the risks in the scenario. They demonstrated a strong awareness of their responsibilities as pilots to ensure the safe transportation of passengers. Their approach was more thorough, and they conveyed their views calmly. This could be attributed to their extensive exposure to diverse destinations with similar adverse weather conditions and their higher total flying hours, particularly monthly hours. These findings align with the research conducted by Li et al. (2003), which showed that pilots with higher total flying hours have a lower risk of crashes due to improved risk perception. Expert pilots also adapt their decision-making strategies using heuristics or analytical approaches based on the specific context, available time, and personal factors (Orasanu & Fisher, 1997).

The observations during the scenario analysis provide additional evidence that novice pilots struggle with risk perception and prioritization compared to expert pilots. Novices prioritize safety but may have a limited understanding of the risks involved, whereas experts consider multiple factors and employ tailored decision strategies. The exposure to diverse flying experiences and accumulated flying hours contribute to the experts' enhanced risk perception and decision-making abilities. These findings highlight the importance of experience, exposure, and ongoing training in developing pilots' risk assessment skills and decision-making capabilities to ensure safe flight operations.

The second part of the scenario question dealt with risk tolerance among the pilots based on the decisions either to continue to land, delay or divert. Although the decisions of the pilots vary, again safety was the main aim relative of their own experience and exposure. Weather conditions was the dominant consideration followed by fuel requirements. Consideration of

other issues varies between the ranks and airline, but it was least considered. Thus, "safety" and their decisions vary according to experience and exposure of the pilots in this research.

Cadet pilots and second officers especially in Airline X made a fast decision to divert while the expert group either decided to hold or continue the approach with a backup plan. They were unsure or doubtful at certain times too. Airline Y pilots again in all the ranks were found to make a more calculated and structured approach to arrive at a decision. The total hours of Airline Y novices are also higher compared to Airline Y indicating more experience. Few of the novice pilots admit that they have not experienced such a situation before which is a fair comment with their limited experience. Their training programs of diversion planning were also only theoretical. The novices tend to display risk-averse attitude with their decision-making influenced by the perceived threats involved. as found by Lopes (1987).

The decision-making process revealed varying levels of risk appetite and risk tolerance among the pilots, as depicted in Table 4.2. Interestingly, the risk tolerance appeared to decrease with higher ranks. However, it is important to note that first officers and captains, despite exhibiting a seemingly reduced risk tolerance, actually engaged in higher-risk decisions compared to cadets and second officers. These experienced pilots were willing to proceed with the approach, navigating through challenging weather conditions in an attempt to land. While focusing on safety, they considered the company's obligation to ensure passengers' safe travel (trade-off) and utilized available resources, such as more information and assistance from air traffic control and other nearby aircraft. They also referred to company policies on fuel and limitations, which set boundaries for their risk assessment. Although their risk tolerance appeared high, it was within their realm of experience and confidence.

Over the course of their careers, expert pilots had encountered and personally experienced most of the presented conditions. Similarly, first officers with significant experience made decisions similar to captains. Many of the first officers interviewed were on the verge of transitioning to the role of captain, awaiting selection. They exhibited proactive behaviour,

gathering more information, displaying a strong understanding of airline policies, and being willing to revise decisions or formulate alternate plans before reaching a final decision. Their approach involved thorough consideration and a willingness to ask questions and seek clarification when in doubt. These behaviours align with the findings of Green (2001), where flight instructors with sufficient experience tend to perceive flying as a less risky activity. However, it is crucial to acknowledge that in an actual flying situation, a captain displaying overconfidence and underestimating risks can convey an incorrect message and instil unwarranted confidence in co-pilots. Overconfidence and underestimation of risks have been identified as factors contributing to accidents (Hunter, 2002; Orasanu et al., 2002; O'Hare, 1990; Drinkwater et al., 2010; Charles, 2015).

Overall, the pilots balance their risk-taking and deciding the important action to take within their experience level. Experts can handle multiple situations and requirements compared to novices. Experience determines their level of perception of risk with safety clearly dominating pilots thinking. They were primarily concerned with reducing threats to flight safety (weather and fuel) while other elements such as delay, and Christmas were secondary or not even considered.

Comparison between Airline X and Airline Y

In the preceding sections, we explored various aspects of risk perception and risk tolerance, as well as the understanding of risk and safety, in both Airline X and Airline Y. This section delves into additional similarities and differences between these two airlines.

Firstly, it is worth noting that both Airline X and Airline Y have achieved global prominence and are widely recognized as leading international carriers. They have garnered reputations for excellence in the industry and boast state-of-the-art facilities. These airlines also allocate substantial budgets for crew training, enabling them to attract highly skilled pilots and provide competitive compensation packages. This emphasis on training and talent acquisition contributes to their overall safety standards and operational efficiency.

Additionally, both Airline X and Airline Y have established cadet pilot programs and command upgrade initiatives. These programs serve as avenues for aspiring pilots to enter the industry and progress in their careers. By nurturing and developing the skills of their pilots, both airlines demonstrate their commitment to cultivating a skilled workforce and ensuring a steady supply of competent aviators.

Pilots from both airlines are well educated with tertiary education. Previous research by Thomson (2004) and Hong et al (2016) indicated education and institution attended influences risk perception and safety and increase learnability among the pilots (Yordonova & Matilda. 2011). Our research findings are in line with those findings. Pilots from both airlines demonstrate a commendable understanding of safety, although their perception of risk may not be entirely accurate. It is worth noting that Airline X predominantly consists of pilots from its own country or neighbouring countries with similar cultures. They primarily consist of locally trained pilots. In contrast, airline Y employs pilots from diverse countries worldwide, and a significant portion of them have prior experience working in multiple airlines before joining Airline Y. As a result, pilots at Airline Y possess broader operational experience, having encountered a wide range of weather conditions, and gained familiarity with various airlines' policies and procedures. This exposure contributes to their resilience, resulting in an enhanced risk perception and greater tolerance for risk compared to pilots at Airline X.

Hence, the composition and backgrounds of pilots in Airline Y, with their extensive operational experience, contribute to their improved risk perception and higher risk tolerance levels. This sets them apart from the predominantly locally trained pilot base of Airline X. However, it is important to note that there may still be some issues regarding Crew Resource Management (CRM) that need to be addressed in both airlines.

Researchers, Knecht (2015) and Pauley (1990) conducted studies exploring pilots' risk perception and risk tolerance in relation to varying weather conditions and display units. Interestingly, in our own research, the weather was presented as one of the factors in the

decision-making scenario. However, the pilots from both airlines did not specifically discuss the usage of weather radar, which is a valuable tool for assessing weather conditions. None of the pilots in our study inquired about the precise location of the adverse weather. Instead, they referred to weather as the primary risk, which is an incorrect identification. In reality, the weather itself is not a risk; instead, it is a hazard. The decision to fly through challenging weather conditions is the risk. This oversight may be attributed to factors such as Plan Continuation Errors (PCE) or a tendency to "press-on" with the flight despite potential risks, as discussed by Oranasu, Burian, Hint (2001); Rhoda & Pawlak (1999); McCoy & Mickunas (2000).

One notable observation from the interviews is the influence of ambiguity and uncertainty in the scenario on pilots' risk perception and risk tolerance, ultimately shaping their decision-making process. It is evident that the inherent nature of the problems presented (conflicting, competing and ambiguous) in the scenario leaves room for multiple choices and no definitive or superior option. Pilots who expressed a preference for continuing the approach tended to focus on their obligations to the company and the importance of completing the assigned task. Conversely, those who opted to divert their course placed greater emphasis on factors such as weather conditions, fuel considerations, and the conditions at the alternate airport. This trend was observed among pilots from both airlines, indicating a common pattern in their decision-making approaches.

The pilots from both airlines expressed their appreciation for the interview sessions and acknowledged the value of the questions, scenarios presented, and discussions. They recognized that the sessions provided them with beneficial insights. Despite the complexity and challenges of the scenarios, the pilots found them thought-provoking and helpful in analysing situations and determining the best course of action for ensuring safety. It was observed that novice pilots and some first officers displayed a degree of reluctance, caution, and apprehension in their responses, possibly due to concerns about providing incorrect answers. The novice pilots mentioned that they had not encountered such demanding situations before. However, first officers recognized

the value of these discussions, especially in the context of command upgrade programs. The captains found the scenarios and questions to be excellent, thought-provoking, and suggested that they should be incorporated into airline training programs to enhance safety, replacing traditional methods.

Conclusion and Recommendations

The research aimed to investigate how airline pilots' risk perception and risk tolerance change as they progress in their careers. 16 pilots from two airlines interviewed. Risk perception is inherently subjective and influenced by personal and work experiences, exposure to different environments, and familiarity with policies and training. By achieving the objectives of the study, important insights were gained into how pilots at different stages of their careers assess and manage various types of risks. The findings revealed that airline pilots demonstrated a safety conscious attitude and awareness of potential flight safety risks. However, not all risks were perceived equally by pilots of different ranks and from both airlines, with some risks considered less impactful on flight safety than others.

Pilots faced conflicting, competing and ambiguous conditions that subjected them to pressure, including complying with airline obligations to passengers, personal reasons, and safety concerns. These factors could potentially lead to risky decision-making. While safety was always stated as paramount, it became evident that there was not a comprehensive understanding of risk, despite its common usage.

The results from the research showed that risk perception and risk tolerance varied between ranks and airlines. Risk perception involved cognitive abilities, whereas risk tolerance was influenced by personality traits. As pilots progressed in their careers and gained more experience, their risk perception improved, while their risk tolerance reduced. These findings were consistent with previous research, highlighting the addictive nature of risk dimensions. As threats and hazards increased, decision-making became more challenging. Flight crews faced dilemmas in accepting a certain degree of risk while maintaining a trade-off between safety, production, and other important elements within a specific space and time, with minimal potential consequences.

The research made significant contributions by employing a unique methodology and conducting interviews with pilots from two different airlines at various stages of their careers. This approach provided valuable insights into the dynamics of risk perception and risk tolerance as pilots progress in their professional journey. While the overall patterns observed aligned with previous research, the inclusion of two specific airline pilots added depth and specificity to the findings. The research emphasized the importance of integrating risk perception and risk tolerance training into pilot training programs, receiving unanimous agreement and appreciation from the interviewed pilots. The methodology, involving interviews with pilots from different airlines and career stages, enhanced the understanding of risk perception and risk tolerance within the aviation industry, shedding light on the influence of factors such as operational experience and exposure to diverse environments.

The research findings indicated that pilots from Airline Y exhibited a higher level of risk perception compared to their counterparts in Airline X. This slight disparity can be attributed to several factors, with one key factor being the extensive exposure and accumulated flying hours of pilots in airline Y. The pilots in airline Y, due to their broader operational experience and greater familiarity with a variety of destinations, developed a heightened sense of risk perception. On the other hand, pilots in Airline X, who primarily operated within their home country or neighbouring regions, had relatively limited exposure to diverse destinations, resulting in a comparatively lower level of risk perception. Overall, the study highlighted the significant impact of exposure and accumulated flying hours on pilots' risk perception, underscoring the importance of diverse operational experiences in cultivating a stronger sense of risk awareness among airline pilots.

To further advance the comprehension of risk perception and risk tolerance among airline pilots, it is recommended to expand the participant pool and increase the sample size in future studies. This can be achieved by incorporating both qualitative and quantitative approaches, such as conducting focus groups, to obtain a more comprehensive understanding of

pilots' perspectives and experiences. Additionally, replicating the research in smaller or low-cost airlines with subpar safety records would offer valuable insights and contribute to the enhancement of risk perception, risk tolerance, and overall risk management and safety within those particular contexts.

In addition, incorporating the use of flight simulators to recreate realistic scenarios resembling those investigated in this study could provide more precise insights into pilots' risk perception and risk tolerance during actual flight operations. By observing pilots at different ranks and in two-person crews as in actual settings during flight within a simulated cockpit environment, a more accurate assessment of their response to risk can be obtained. This approach would offer a valuable opportunity to assess how pilots perceive and manage risks in a controlled yet authentic setting, providing valuable data for further enhancing flight safety measures. By implementing these recommendations, future research endeavours can deepen our understanding of how pilots perceive and manage risks, leading to the development of more effective strategies to ensure flight safety.

The research encountered several challenges throughout the process. One of the major challenges was obtaining participants' agreement to be interviewed, as many pilots were concerned that the results might be used against them, particularly novice pilots (cadet pilots and second officers). Additionally, the cautious nature of pilots in providing answers and prioritizing safety in their responses posed another challenge. The research was also impacted by the COVID-19 pandemic, leading to reduced motivation and difficulties in face-to-face meetings with the co-author for discussions and coordination.

In conclusion, this research emphasizes the significance of addressing risk perception and risk tolerance in pilot training programs to enhance flight safety, providing valuable insights into the evolving dynamics of these factors among airline pilots throughout their careers. The study highlights the need for targeted training programs and enhanced awareness campaigns to effectively manage risks in aviation operations. Furthermore, the findings reveal that the sample

of pilots in this research exhibit a safety-conscious attitude and possess an awareness of flight safety. As pilots progress in their careers, their risk perception improves while their risk tolerance reduces, aligning with previous studies. By equipping pilots with the necessary knowledge and tools such as meteorological knowledge, aircraft systems, communications, ATC procedures air law, emergency procedures and human factors, flight operations can continuously improve risk management practices. However, not all risks are perceived equally, indicating the importance of ongoing training and awareness initiatives to address potential gaps. This underscores the role of experience, exposure, and knowledge in shaping pilots' assessment and management of risks. By proactively addressing these aspects, airlines can foster a safety-centric culture that effectively identifies and mitigates risks, ensuring the well-being of passengers, crew members, and the aviation industry as a whole. Overall, the study underscores the need for a comprehensive approach to risk perception and risk tolerance in pilot training, enabling the aviation industry to cultivate a safety culture that effectively identifies and mitigates risks for the highest standards of flight safety.

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Appendices

Appendix 1.1: Demographic Airline X

No	Topic/Pilots Groups	XCP1	XCP2	XSO1	XSO2	XFO1	XFO2	XCT1	XCT2
1.	Rank	Cadet 1	Cadet 2	SO 1	SO 2	FO 1	FO 2	CAPT 1	CAPT 2
2.	Type of License	PPL Frozen ATPL	PPL Frozen ATPL	MPL/ Frozen ATPL	MPL/ Frozen ATPL	CPL/ATPL	CPL/ATPL	CPL/ATPL	CPL/ATPL
3.	Educational Level	Degree Mechanical	Degree Psychology	Degree Aeronautical	Degree Electrical	Degree Economics	A Levels	O Level	Degree Mechanical
4.	Current Fleet (Duration in the Fleet)	Cessna 172 4 months	Cessna 172 2 months	B737 8 months	A350 10 months	B787 3 years	B787 3.5 years	A380 8 years	A350 1.5 years
5.	Types of aircraft flown	Cessna 172	Cessna 172	Cessna 172 B777 (Simulator) B737	Cessna 172 B777 (Simulator) A350	Cessna 172 Beechcraft Baron B777 B787	Cessna 172 Beechcraft Baron Learjet 45 B777/B787	Cessna 152/172 Beechcraft Baron B727/B747 A310/A340 A380	Cessna 152/172 Beechcraft Baron Learjet 45 B777/B787 A350/A350
6.	Types of rating (VFR/IFR)	VFR/IFR	VFR/IFR	VFR/IFR	VFR/IFR	VFR/IFR	VFR/IFR	VFR/IFR	VFR/IFR
7.	Training Position	Nil	Nil	Nil	Nil	Nil	Yes Supervisory FO	Nil	Yes Supervisory Captain
8.	Management Position	Nil	Nil	Nil	Nil	Nil	Yes (Pilot Special Duties)	Nil	Yes Fleet Safety
9.	Age	34	30	31	34	37	37	63	52
10.	Total Hours (Approx)	81	65	250	300	4500	9400	22000	18000
11.	Gender	Male	Male	Male	Male	Male	Male	Male	Male
12.	Marital Status	Single	Single	Single	Single	Married	Married	Married	Married
13.	Previous Experience (GA/Military Etc)	LAE	Student	Engineer (Oil & GAS)	Cabin Crew	Engineer	Student	Student	Engineer
14.	Total Duration in the Airline	2 years	3 years	3.5 years	4 years	12 years	17 years	43 years	24 years
15.	Total duration in the position	2 years	3 years	10 months	2 years	7 years	14.5 years	32 years	11 years
16.	Total Interview Time (minutes)	40	40	35	45	55	50	60	55
17.	Location of Interview	Virtual	Virtual	Face to Face	Flightdeck	Flightdeck	Flightdeck	Face to Face	Flightdeck
18.	Both authors Interviewed Together or Separately	Together	Together	Together	Separately	Separately	Separately	Together	Separately

Appendix 1.2: Demographic Airline Y

No.	Topic/Pilots Groups	YCP1	YCP2	YSO1	YSO2	YFO1	YFO2	YCT1	YCT2
1.	Rank	Cadet	Cadet	JFO1	JFO2	SFO1	SFO2	CP1	CP2
2.	Type of License	CPL Frozen ATPL	PPL Frozen ATPL	ATPL	ATPL	ATPL	ATPL	ATPL	ATPL
3.	Educational Level	Foundation Engineering	Degree Engineering	Degree	College	Medical Degree	University Degree	University Degree	University Degree
4.	Current Fleet (Duration in the Fleet)	Cirrus 6 months	Phenom 3 months	B777 3 Years	B777 3 Years	B777 8 Years	B777 6 Years	B777 13 Years	B777 10 Years
5.	Types of aircraft flown	Cirrus	Cirrus Phenom	Cirrus Phenom King Air Embraer B777	Cirrus Phenom B777	Cirrus Phenom B777	Cessna Caravan B737 B777	Cessna 172 Embraer B737 B777	Cessna 172 PA28 Fokker50 B737 B777
6.	Types of rating (VFR/IFR)	VFR/IFR	VFR/IFR	VFR/IFR	VFR/IFR	VFR/IFR	VFR/IFR	VFR/IFR	VFR/IFR
7.	Training Position	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
8.	Management Position	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
9.	Age	25	26	30	26	35	41	43	48
10.	Total Hours (approximate)	100	235	1000	1300	8000	13000	15000	15000
11.	Gender	Male	Male	Male	Male	Male	Male	Male	Male
12.	Marital Status	Single	Single	Single	Single	Married	Married	Divorced	Married
13.	Previous Experience (GA/Military Etc)	Student	Student	Airline Pilot	Student	Medical Doctor	GA Pilot	Airline Pilot	Engineer
14.	Total Duration in the Airline	10 months	2.3 years	3 Years	3.5 Years	11 Years	12 Years	23 Years	22 Years
15.	Total duration in the position	6 months	1.5 years	2 Years	3 Years	5 Years	6 Years	13 Years	10 Years
16	Total Interview Time (minutes)	40	43	45	45	45	40	45	45
17.	Location of Interview	Virtual	Virtual	Flightdeck	Flightdeck	Virtual	Flightdeck	Flightdeck	Virtual
18.	Both authors Interviewed Together or Separately	Together	Separately	Separately	Separately	Together	Separately	Separately	Together

Appendix 2: Interview Questions

Section A Demographic		
No	**Questions**	**Data**
1.	Rank	
2.	Type of License	
3.	Educational Level	
4.	Current Fleet (Duration in the Fleet)	
5.	Types of aircraft flown	
6.	Types of rating (VFR/IFR)	
7.	Training Position	
8.	Management Position	
9.	Age	
10.	Total Hours (approximate)	
11.	Gender	
12.	Marital Status	
13.	Previous Experience (GA/Military Etc)	
14.	Total Duration in the Airline	
15.	Total Duration in the position	
16	Total Interview Time (minutes)	
17.	Location of Interview	
18.	Both authors Interviewed Together or Separately	

Section B

Scenario

A hypothetical decision scenario during an approach and landing phase with aggravated conditions is presented to the pilots. However, only general conditions are provided without any specific details. This is to keep the scenario open, and detailed conditions provided only when required/questioned by the pilots. The conditions described pose a threat to flight safety. Stress elements, time pressure and ambiguity are introduced (weather delay and possibility of missing out of family celebration - Christmas). The purpose is to observe and understand how the pilots identify hazards, perceive the risk involved and evaluate the risks. What are the considerations and actions taken accordingly in this dynamic, uncertain conditions, time pressure with goal conflicts between safety and other goals (economy, productivity, customer satisfaction, reputation etc)? Pilots had to decide on a course of action: to continue with the approach, delay or to divert. At each point in time, pilots could ask for more information than was presented in the event description. Pilots we encouraged to think aloud about their concerns and reasoning while they decided on how they would proceed at each point in the evolving event.

Event Description

You are now at the top of descend preparing for an approach into an airport. Just received the latest weather report. A huge thunderstorm cell is over the approach path. Heavy rain, tailwind and windshear are reported at the airport. The preliminary report at departure did not indicate any of these conditions. Aircraft is not able to conduct the instrument landing system (ILS) approach due to an aircraft technical system malfunction.

Further, you departed late; hence the current estimate shows that you will be arriving late at your destination. Most of the passengers have connecting flights. Tomorrow is Christmas. You too have an appointment with someone for an important matter. There is a curfew looming at the airport.

No	Questions	Answers
1.	What is your overall view of the situation?	
2.	What are your considerations? (Goals/Priorities etc)?	
3.	What is your decision? Continue, Delay the Approach or Divert. Why?	
4.	How do you arrive at the decision?	
5.	What are the resources did you consider in your decisions?	
6.	Do you think it's a safe decision?	
7.	Any other view/comments/feedback?	

Section C Risk Perception and Risk Tolerance		
No	**Question**	**Answers**
1.	What is Risk? What are the terms/words/phrases that are related to risk comes to your mind?	
2.	What are the types of risks that come to your mind during your work (flight operations)? How often each of these types of risk influences your decision making?	
3.	What is Safety?	
4.	Is Risk & Safety related? Why and How ?	
5.	Based on the scenario shared above, could this event happen to you? What was your experience and how it was handled/prevented? Besides that, are you involved in any incidents or accidents within and outside your job? (Actual/Potential) Any examples? What is the frequency?	
6.	Do you know anyone who is involved in an incident & accident? Why did that accident happen? Could it be avoided? Is he/she being a risk taker? If was you in the same scenario, would you have avoided it?	
7.	Are you a risk taker? 1-10 Does your risk perception change along your career? How? Can you give an example? Does your risk tolerance change during your career? How? Can you give an example?	
8.	Are you aware of the operational, safety and risk policies in your organization (flight operations)? What are those? How does it influence your decisions? How does the operational policies and training assist (CRM/TEM) assist your decision making? Do you think current policies are sufficient?	
10.	Any other view/comments/feedback?	

Appendix 3: Transcripts of Interview

Question 1: Pilots overall view/understanding of the situation (scenario) presented, their considerations (goals, priorities, objectives) and resources used.

XCP1: "From the scenario presented, what strikes me first is the weather condition. The thunderstorm at the approach path "scares me"… I am worried if I can land safely. I actually do not know if I should call the ATC for assistance".

XCP2: "With my limited flying experience, I have not seen this type of weather yet. Most of the time the weather here is very good and clear skies. I am only trained for visual approaches for now… I am alone here. I need to think who can assist me".

YCP1: "Bad weather, ILS unserviceable and carrying no extra fuel are my considerations. I will opt to hold and request for another runway and will not rush into diverting yet. With the current situation with the visibility and wind component, I would be prepared to go around and if I do go around, I will evaluate if the fuel is sufficient and prepare by requesting the alternate weather. The passengers are of priority in accordance with the company's obligation to take them to the destination too. However, I will put the emphasis on the safety of the crew, passengers, and the aircraft".

YCP2: "I am feeling anxious and stress full about the situation. Weather is everywhere. I have been a passenger in one of this type of weather. My concern and my goals are safety, especially threats for the aircraft, pax and the crew. The resource I can think about now is the available fuel and I am not sure about the flight time limit. Hmm..i should gain more experience as I can more experience and have a better picture"

XSO1: "After reading the scenario, I can see the weather issues as main concern. My goal is to land safely, but I have not come across this type of *"complex situation"*. I need to re-calculate the fuel now".

XSO2: "Goal is to land. A bit pressured. Weather is terrible"

YSO1: "My overall concern is the weather, which are the wind shear and thunderstorm activities, and my main priority is to land. I would continue the initial plan with the descent initiation and constantly re-evaluate, taking into account the fuel and operations policies of the airline".

YSO2: "If I am not comfortable with the situation that I am facing, I will not commit as safety is important". I will hold while monitoring the fuel available and work out a time when a diversion will become necessary. With the weather all around, I will also consider a non-standard missed approach procedure. The choice of approach itself will depend on the location of the storm. For me, all scenarios have zero prioritisation as safety is the most important aspect". If fuel is available, he would continue to hold".

XFO1: "Weather, curfew, ILS, Christmas. Can't achieve everything. Use as many resources as I can, ATC, other crew, and ops centre to help in decisions. Always want to land safely".
XFO2: "I can see a few issues here. Weather is number one. Not so good today. Hmm that's coupled with the ILS failure. We are late, its OK. No luck, I will miss Christmas this year, we'll. My friend, I can talk to him later. He understands my job"…My priority is to land safely, I may need to consider other options too. I will try to get more information from ATC."

YFO1: "Overall, I acknowledge that there are a lot of factors involved in the decision making such as the challenging weather and time pressure. Safety is my priority. Secondly legality and then comes the other commercial considerations. I will not rush into deciding without thoroughly evaluating the reports that come from the destination airport. Meanwhile, I will prepare for plan B and gather more information should I decide to divert to the alternate airport".

YFO2: "The un-forecasted bad weather during the Christmas rush and the challenges in decision making the major factors here. I will consider the fuel, holding time available and evaluate the alternates while continuing with the original plan till such time the need to divert arises. Even though commercially, the best option is to continue to destination I am mindful that we might not be able to land".

XCT1: "Well, what's new here. I have seen these many times, maybe worse than this. You want to hear ….? My priority is of course to land safely, either at destination or alternate. I have many resources, ATC, my co-pilot, company, and ACARS. No ILS, *"so what"* we can use RNAV or just visual. As long as, I have sufficient fuel, can be managed".
Another captain also had similar comments but was more methodological in his assessment.

XCT2: "Past one week, this is how the weather here. I need enough fuel first. My options will be bigger. Where is the thunderstorm exactly? I will base my considerations based on the fuel and operations policy and the limitations. Other issues not so important for me - my friend can wait to see me. Missing Christmas, this is not my first time. I don't want to rush to meet the curfew. Will inform the company earlier."

YCT1: "My first approach was to deal with the weather and to probe more details from the ATC for its trend; to determine if the weather is transient or lasting against the fuel available. His other consideration was renominating a closer alternate. I will find out if another choice of runway is available and then evaluate the risk of commencing the approach without the ILS. My utmost priority is safety, and we would live to celebrate many more Christmases. I will also use all available resources such as the ATC, weather radar, preceding aircraft encounters or even negotiate an extension of the curfew with ATC".

YCT2: "I recognise the fact that Christmas and the looming curfew are minor considerations for me. My priority is safety and the fuel available. I will consider the best approach available and the weather trend and keep a good listening watch to what the preceding aircraft and the other aircraft's actions. The choice of alternates of the others are also important, as parking space availability will be a concern later as ATC might decline our preferred airport. More details on the type of contamination affecting the destination will be another concern. I will evaluate the chances of a successful landing at the destination with the given weather. The Flight Time Limitations need to be respected and I will ensure that no rules are broken. If needed, I will use the captain's discretion in order to arrive at the best decision. The ATC, company policies and dispatch updates from the company will be my important resources".

Question2: Pilot's decision (Continue and Land, delay the approach or divert), decision making process and is it a safe decision. Any previous similar experience
XCP1: "I think the weather is really bad. I will divert to the nearest airport which I just flew over. I think this is the safest thing to do. But I need to explain to my instructor later."
Cadet pilot XCP2 revealed something interesting about the training that diversions are not taught to them. Both the cadets in airline X are going through the MPL program which is airline specific and has very little solo hours requirement.

XCP2: "Actually I have never done a diversion but I think to be safe I better do that. I have almost full tank. We fill up full for all our sorties every time. During training this not been discussed or taught to us. Always at the circuit area or training area"

YCP1: "I think I will hold and that maybe is a safe decision. It is a safe decision as I considered the Swiss Cheese Model. Low fuel could be an issue and in order to avoid possible fuel emergency, I have to act fast".

YCP2: "I will hold and delay. Because I was unsure of the extent of the weather. Yes, I believe it's a safe decision".

XSO1: "My decision will be to divert but to tell the truth, I am not very sure. I've heard my friends have done diversion but that was due to fuel. They were asked to hold as there were many arrivals" I am not sure how much fuel do I have. Maybe, I should wait for a while. Difficult to make a decision. There are a few other things I also need to consider. But I will try to make the safest decision".

XSO2: "I will leave it to the captain. He will decide. My opinion is that he will make the safest decision".

YSO1: "I will probe the ATC for more specifics for the situation at the airport such as if any other aircraft have successfully landed, current weather observations and the company policies regarding tailwinds for landing. Yes, I think that is a safe decision".

YSO2: "My planning would have started at the top of descent point, especially in evaluation of the alternates and probe ATC for more information pertaining the weather, success of approach by other aircraft and always be prepared to go-around and divert".

XFO1: "Definitely I will ensure my decision is the safest. For now, I don't have a concrete decision, but I need to gather more information. More details on weather, I will get more updates, listen out, and will talk to my captain. We may have to hold to make the best/safest decision. So, for now I need to buy some time. If the weather goes pass the FO limit (the wind and visibility), the captain have to take over the landing."

XFO 2: "I have had some similar situation. We ended up landing. The weather was not so bad, actually. I will discuss with my team and update the weather. ATC can be a good and quick resource. I will look at the co-pilot limits in the policy and fuel requirements for diversion. It may be more challenging if it's at night. I need to consider runway conditions. Others like curfew, friends and celebration do not matter much at this time. I will keep the option open. Safety is paramount at all times."

YFO1: "I will use resources such as ATC, weather reports and also any successful landings conducted by other aircraft. The resources that I gather will also be used for my Plan B consideration. I will also engage the company to help me gather more information. Plan B is a safer decision and as I am paid to make a safe decision".

YFO2: "I will use all resources available to me at that time such as the ATC, company, other aircrafts, weather trend forecast and the actual weather reports in order to arrive at the safest decision".

XCT1: "If it's scared the shit out of me, I will press the TOGA and go. I will make sure I have enough fuel, but I will try the approach. I may consider another runway and get updates from ATC. I am sure the ATC understand our situation. Maybe can negotiate the curfew time".

XCT2: "Lesson I learned over the years, don't bust any policy. I will continue the approach with GA options always available. Stabilised criteria must be ensured. If need to just go around. Will consider all resources .. (ATC, other aircraft nearby and may call the company to update due the curfew). Planning must start early".

YCT1: "If the odds are stacked up against me, I will consider a diversion. I would be using all available resources such as the ATC, weather radar, preceding aircraft encounters or even negotiate an extension of the curfew with ATC. Nevertheless, diverting will be a safe decision. I have encountered similar situations that had been challenging even though not identical."

YCT2: "I will consider the chances of a successful landing at the destination with the given weather. Additionally, I would consider the Flight Time Limitations. I will ensure that no rules are broken in the process. I will engage the ATC, company, and seek information from other aircrafts in the vicinity."

Question 3: At the end of section B of the questionnaire, we seek-ed feedback on the scenario and any additional points that the pilots would like to highlight. Almost all the pilots mentioned that the scenarios were good and this "complex" situation although has not happened (and they wish it will never happen to them) was good training for them.

XCP1: "Tough man. But I learned".

XCP2: "It was a difficult scenario but definitely useful for us when we become second officer and first officer after the training is completed"

YCP1: "Actually, this can happen to anyone. I have had a similar predicament in which I chose not to depart. Yes, I chose to avoid it. But this was during my flight training school days. I have gained some insights into the real world of flying."

YCP2: "Scenario is clear but uncertain. I may face this someday although I hope not. Practical question, I believe".

XSO1: "Definitely useful for me. I will think about it again and maybe discuss it with my instructors. Surely useful for me in the future".

XSO2: "Yes, it a hard situation. I was trying to think how to deal with this scenario but definitely I need help. Very good for me to prepare for the future.

YSO1: "Of course this happened before but to someone that I know. It turned out to be a learning experience to me. It's better to learn from someone else's experience first. Nevertheless, I admit that this scenario made me think of the possibilities that I might have to face some day when I becomes the captain".

YSO2 : "I have experienced this before but it didn't happen at the Top of Descent, so I had the luxury of time and I anticipated it well. One of my such flights resulted in a diversion but the rest were successful landings at the destination."

XFO1: “A bit stress and hope this don’t happen to me but I must be ready especially when I a captain in future. Good questions, discussion, and learning points for me”.

XFO2: “Thanks for giving us the opportunity to discuss about this scenario. Surely helpful for our command upgrade. I have not thought some of the point that being pointed out”.

YFO1 : “This scenario would give confidence in safety related matters to any operator. It encourages an open flight deck communication and is CRM (Crew Resource Management) orientated. I also think that this scenario can be successful with a flat gradient flight deck.”

YFO2 : “I have experienced similar scenario but to a lesser extent where had to divert to the alternate airport. Our destination was closed due to fog and the outcome was a good and well handled one. The diversion went on smoothly.”

XCT1: “This is a good scenario and discussion items. Will be useful for me when I am doing the training”.

XCT2: “Definitely good questions with multiple conflicting objectives, but we need to know what’s important for safety. We carry lives and company reputation. Very good scenario for the co-pilots”.

YCT1: “I have experienced something but half the intensity of that stated in the scenario. But then I was already an experienced captain when that happened”.

YCT2: “My experience is quite similar to the scenario presented to me. The destination was experiencing typhoon and gusty winds. We managed to land after holding for some time. This scenario would have aided more if it was presented to me prior to that experience, early in my command years. Nevertheless, we had a safe outcome; yes, we landed without any incident”.

Appendix 4: Participant Informed Concerned Form

Student Investigators: Kannan Perumal & Chandrasegaran Mariappan

Research Supervisor: Prof Dr Eder Henrique

Project Purpose & Procedure
This research project is conducted as partial fulfilment of the MSc Human Factors & Systems Safety Lund University.
Participants will be presented with a scenario to read, followed by a series of questions related to the scenario. In addition, there will be additional discussion questions to foster further conversation. The anticipated duration for the activity is approximately 1 hour.
The information collected from all participants will be subsequently utilized for research analysis and to achieve the objectives of the study.

Confidentiality:
Identity of all participants remain anonymous and will be kept confidential from all other parties other than the interviewers. Voice recording and notes will be taken during the interview for the purpose of recall and analysis.
Participants names, voice recordings and notes will be disposed not later than 3 months after the thesis is accepted by the university.

Risk & Benefits:
While no known risks are associated with this research, we anticipate that participants will derive benefits from engaging in the discussions.

Consent:
Participation in this research is completely voluntary. You have the right to refuse, participate, or withdraw from the study at any time, as well as the freedom to ask any questions regarding the research.
Your signature indicates that you have received a copy of this consent form for your own records and that you consent to participate in this research.

I, _____ agree to participate in this research. My participation in this research is voluntary and I understand that I can withdraw at any time.

_____ _____

Participant Name Date