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Examining the Effects of Payload Type and Framing on Weather-Related Decision-Making in A Simulated Urban Air Mobility (UAM) Environment

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by

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Examining the Effects of Payload Type and Framing on Weather-Related Decision-Making in A Simulated Urban Air Mobility (UAM) Environment

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Abstract

TITLE: Examining the Effects of Payload Type and Framing on Weather-Related Decision-Making in A Simulated Urban Air Mobility (UAM) Environment

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The purpose of the current research study was two-fold. First, the study examined the effect of payload type on the riskiness of weather-related decision-making in a simulated urban air mobility (UAM) environment. Second, the current study examined whether framing information using prospect theory (Kahneman & Tversky, 1979) could influence the riskiness of weather-related decision-making in a simulated UAM environment. In the context of the current study, riskiness referred to the risk associated with the decision outcome, specifically whether participants selected a risk-averse decision outcome (return to the departure site) or risk-seeking decision outcome (continue to the destination site) based on the weather conditions in the scenario. The payload type was defined as whether there were cargo or passengers onboard and served as a manipulation of the construct of utility. Payload was not found to impact whether participants made a more risk-averse or risk-seeking decision; however, when asked the degree to which they agreed with their decision to continue or return, there was a significant effect of payload type on their response with participants on average agreeing to divert with passenger payload and to neither agree to divert nor continue with cargo as payload. Frame had a significant influence on the riskiness of decision outcomes. Participants were found to be more risk-seeking (continuing to the destination site more) for loss-framed scenarios and more risk-averse (returning to the departure site more) for gain-framed scenarios. Limitations, implications, and recommendations are discussed.

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DEDICATION

This thesis is dedicated to my father, José Xavier Chaparro.
I hope you know that you are my entire world and will always have my heart.

List of Abbreviations

AAM	Advanced Air Mobility
AGL	Above Ground Level
ATM	Air Traffic Management
CATMOD	Categorical Data Modeling
eVTOL	electric Vertical Take-Off and Landing
GA	General Aviation
HAI	Helicopter Association International
IRB	Institutional Review Board
IMC	Instrument Meteorological Conditions
JFK	John F. Kennedy International Airport
MANOVA	Multivariate Analysis of Variance
NAFI	National Association of Flight Instructors
NASA-TLX	NASA-Task Load Index
RPS	Risk Propensity Scale
UAM	Urban Air Mobility

UAS	Unmanned Aircraft System
UAV	Unmanned Aircraft Vehicle
VFR	Visual Flight Rules

Chapter 1

Introduction

Background and Purpose

Background

Urban Air Mobility (UAM) is an emerging field in aviation that seeks to create secure and efficient air transport for passengers and cargo (Patterson et al., 2018). UAM will utilize highly automated electric vertical takeoff and landing (eVTOL) aircraft to transport passengers or cargo in a metropolitan area for remotely controlled and directly controlled aircraft systems (Lascara et al., 2019; Thipphavong et al., 2018). A major challenge for UAM will be that aircraft will be operating in a high-risk, congested environment as a function of flying near urban infrastructures and at lower altitudes (Greenfeld, 2019; Hamilton, 2018; Air, 2018; Cenk Ertuk, 2020; Cokorilo, 2020; NASA, 2018). UAM aircraft operations are proposed to operate under visual flight rules (VFR) not to exceed 5,000 feet (Cokorilo, 2020; Patterson et al., 2018) with an average flight duration of 20 minutes. For approximately half of the flight (i.e., during descent and ascent) the aircraft will be navigating in proximity to buildings (Cokorilo, 2020). The lower altitudes in which eVTOLs will operate compared to traditional aviation contexts will yield different weather challenges and constraints (Patterson et al., 2018), such as mechanical turbulence around large buildings. Additionally, there is no current Air Traffic Management (ATM) that can reliably lend UAM pilots weather support at these altitudes (Lascara et al., 2019), an issue that helicopter pilots commonly face as weather information at lower altitudes is sparse if at all present (Ramee et al., 2021).

Even further compounding the issue is that UAM operations will ultimately be remotely controlled. Therefore, much like remote pilots, UAM pilots will not have access to all of the information that is available to pilots on board an aircraft. Remote operations reduce the sensory cues that pilots onboard the aircraft can use, such as the feeling the turbulence onboard the aircraft (Helmreich, 2000; Hobbs & Lyall, 2016). As a result, weather will be a critical factor UAM pilots will face due to navigating in these lower and novel airspaces (Cokorilo, 2020; Hamilton, 2018; Patterson et al., 2018). Weather-related accidents, although not the leading cause of accidents in aviation, commonly lead to high numbers of fatalities when they do take place, leading weather-related accidents to be labeled as a concern for general aviation (GA) pilots and small commercial operators (Baron, 2011; Ramee et al., 2021; Walmsley & Gilbey, 2020). This is of concern to UAM as the pilots who have been identified as likely to be selected for UAM fall within this category. Research related to fatal weather-related aviation accidents has pointed to ineffective decision-making by pilots as a large contributor (Wiggins et al., 1999; Hunter, 2006; Walmsey & Gilbey, 2020).

Operations similar to UAM that used helicopters as air taxis operated for decades and have ceased due to safety concerns (Garrow et al., 2020). Furthermore, during the last 2 decades, the accident rate in aviation has significantly reduced and the air traffic rate increased by more than 86% (Cokorilo, 2020). It is clear that ensuring safe operations will be important for consumers to adopt UAM, and for UAM operations to succeed. Pilot decision-making has been recognized as a critical factor in safe aircraft operation and accident avoidance for many years (FAA, 2009). One step in creating this safe and efficient UAM air transportation system for passengers and cargo will be to understand how the riskiness of weather-related decision-making will affect these novel conditions, with a range of different payloads. Further, weather has been identified as a critical safety challenge in the UAM space, so ensuring that pilots make effective weather-related decisions is important (Cokorilo, 2020).

To ensure the safety of both passengers and cargo, UAM pilots must make appropriate decisions related to weather, preferably erring on the side of caution as the level of risk increases. Decision times must be quicker than that of regular aviation pilots, and decision-making must be just as effective. The novel UAM environment will likely require a time condensed decision-making process, in which time-pressure has been shown to reduce the quality of decision-making in pilots (Maule et al., 2000; Payne et al., 1995). Pilots have been found to be less thorough when pressed to make a decision in a short time frame (Khoo & Mosier, 2005; Mosier et al., 2007). As such, it is important to understand influences on decision-making in this context.

Leveraging framing, a facet of Kahneman and Tversky's (1979) prospect theory, is a potential means of encouraging pilots to perform low-risk weather-related decision-making is leveraging framing. Prospect theory predicts that when information is framed to highlight the potential losses associated with the decision options, an individual will respond in a risk-seeking manner. Conversely, if information is framed in terms of gains, individuals will likely respond in a risk-averse manner. Prospect theory has been examined by a limited number of researchers in an aviation context. Most notably, O'Hare and Smitheram (1995) examined the application of prospect theory to pilots' decisions about whether to continue into deteriorating weather, specifically visual flight rules into instrument meteorological conditions (VFR-into-IMC). Prospect theory predicts that if a situation is framed in terms of losses, an individual will respond in a risk-seeking manner and will continue to the planned destination. On the other hand, in a scenario framed in terms of gains, individuals will likely respond in a risk-averse manner and seek to either return to the departure site or an alternative site. O'Hare and Smitheram's results found that pilots were more risky, deciding to continue to the destination more often than divert the flight, supporting the influence of framing on weather-related decision-making. The current study was an extension of O'Hare and Smitheram's study and examined the riskiness of weather-related decision-making, in the context of UAM operations. In the context of the current study, riskiness referred to the risk associated with the decision outcome, specifically whether a participant selects a risk-averse decision option (i.e., returning to the departure site in the face of marginal weather) or a risk-seeking decision outcome (i.e., continuing to the destination site in the face of marginal weather). The current study extended O'Hare and Smitheram's research in two key ways. First, the current study examined the impact of framing on the riskiness of weather-related decision-making in a new performance context, that of a remotely-piloted eVTOL aircraft. No studies to date have examined how remotely-piloted operations will affect weather-related decision-making in this type of context. As pilots are not onboard the aircraft, their lives are not at stake, therefore their perspective may be different.

Second, the current study extended O'Hare and Smitheram's (1995) work by manipulating utility, or the subjective value of the potential loss/gain associated with the riskiness of the weather-related decision by manipulating the payload onboard the remotely-piloted eVTOL aircraft (i.e., whether or not humans were onboard). Other framing studies have manipulated utility, however, they are overwhelmingly conducted in other contexts such as finance and gambles (Barberis, 2013; Fagley & Miller, 1997; Ronnlund et al., 2005). Only one study in the aviation context utilized framing and manipulated utility related to weather-related decision-making. Walmsley and Gilbey (2020) examined the effects of framing and utility in 10 flight scenarios, manipulating utility hand-in-hand with framing by using different reference points (i.e., money or time that could be lost or gained based on the frame used). However, results were mixed, only gain-framed scenarios consistently yielded framing effects (risk-aversion) whereas not all loss-framed scenarios yielded framing effects (risk-seeking). Further, the results related to the utility manipulation were not consistent with prospect theory as scenarios that were expected to hold higher utility did not lead to higher risk-seeking compared to those with lower utility. These results may be due to ceiling or floor effects, as the utility levels may not have been different enough to produce a difference in decision-making. The current study aimed to utilize a larger difference in utility between options by manipulating the type of payload onboard the aircraft: whether there was human life onboard the aircraft or not. It was anticipated that loss of human life would have a subjective value that outweighs that of the loss of cargo. There is a wealth of literature examining the differences in the riskiness of decisions related to the loss of human lives (Druckman, 2001; Jou et al., 1996; Kahneman & Tversky, 1982; Roszkowski & Snelbecker, 1990; Zhou et al., 2021) . Much of the literature uses the “Asian disease problem” in which the loss and gains are relative to human lives compared to an inanimate object such as a home. In those instances, the differences in utility are more pronounced and decisions that involve a loss of human lives have been found to lead to higher risk-seeking compared to decisions regarding inanimate objects. The current work manipulated utility by using passengers and cargo further extending the body of work related to the manipulation of utility in the aviation context.

Purpose

Therefore, the purpose of the current research study was two-fold. First, the current study examined whether framing information using prospect theory (Kahneman & Tversky, 1979) could influence the riskiness of weather-related decision-making in a simulated UAM environment. Participants were asked to make a choice between whether they wished to continue to their destination site (risk-seeking decision outcome) or return to the departure site (risk-averse decision outcome) based on the weather conditions in the scenario. Framing was provided to the participants via their decision options in either a loss frame that highlighted the negative features associated with a decision outcome (e.g., broken packages, unhappy passengers, and a tarnished record) or gain frame that highlighted the positive features associated with the decision outcome (e.g., passenger safety, on-time arrival, and pleasant flight environment). Second, the study examined the effect of payload type on the riskiness of weather-related decision-making in a simulated UAM environment. The payload type was defined as whether there were cargo or passengers onboard the aircraft, and served as a manipulation of the construct of utility, defined as the degree to which an individual experiences satisfaction or dissatisfaction associated with a decision outcome (Kahneman & Tversky, 1979).

Definition of Terms

Presented in this section are definitions of terms in the context of this study.

1. *Age* was a self-reported free-response question in which participants reported their age, in years, at the time of the study.
2. *AGL* is the acronym for above ground level, the distance in feet that the aircraft is above the ground or objects, such as buildings, below it.

3. *ATC* is the acronym for air traffic control, and represents ground-based personnel who help maintain safe separation between aircraft and ensure pilots do not fly planes into obstacles through a given section of controlled airspace (Pape et al., 2022).
4. *Biological sex at birth* was defined as a participants self-reported sex and was collected using a researcher developed 1-item, 3-point multiple choice response question, with the options of “male”, “female”, and “I prefer not to answer”.
5. *Decision time* was the amount of time in seconds that it took the participant to make a decision. Time started when the researcher presented the decision alternatives and ended when the participant selected the continue button (after making their decision).
6. *Demographics* are statistical information related to the sample and/or population to determine whether the participants in the sample used for the study are representative of the target population for generalization purposes. In the context of the current study this was the collection of age, ethnic background, biological sex at birth, UAM class experience, type of flight experience, flight hours, video game experience, video game frequency, and UAS experience.

7. *eVTOL* is an acronym for electric vertical take-off and landing, an aircraft that uses electric power to hover, take off, and land vertically. In the context of the current study, these are the aircraft used for UAM operations and therefore the type of simulated vehicle used for the study.
8. *Ethnic background* represented participants' self-reported ethnic background, presented as a 5-point multiple choice response question including an "other" option for individuals whose background did not fall into the named options.
9. *Flight hours* was a three-item self-report question asking participants, "How many flight hours do you have in fixed wing aircraft? ", "How many flight hours do you have in rotary wing aircraft? ", "How many hours do you have flying a UAS?" with a free-response box for each.
10. *Framing* refers to presenting information in either a loss frame that highlights the negative features associated with a decision outcome or a gain frame that highlights the positive features associated with the decision outcome, to influence decision-making (Kahenman & Tversky, 1979). In the context of the current study, gain framing was performed by highlighting positive features such as passenger safety, on-time

arrival, and pleasant flight environment whereas loss framing was performed by highlighting negative features such as broken packages, unhappy passengers, and a tarnished record.

11. *GA* is an acronym for General Aviation, and represents a diverse range of aviation activities that includes all segments of the aviation industry except commercial air carriers (including commuter/ regional airlines) and military; aircraft range from the one-seat single-engine piston aircraft to the long-range corporate jet, and also include gliders and amateur-built aircraft (FAA, 2002). In the context of the current study, GA pilots are representative of the future UAM pilots.
12. *HAI* is an acronym for Helicopter Association International, a not-for-profit professional trade association of 2,500-plus member organizations in more than 68 nations. In the context of the current study, HAI pilots were part of the target and accessible population as they are representative of future UAM pilots.
13. *Payload* is defined as the type of shipment being transported (Scalea et al., 2021). In the context of the current study payload refers to whether passengers or cargo are aboard the aircraft. Payload served as a

manipulation of utility. The current study used either passengers aboard the aircraft or cargo in the form of Amazon packages.

14. *Prospect theory* is a theory of decision-making that describes how individuals make decisions when presented with options that involve risk and/or uncertainty (Kahneman & Tversky, 1979). Information related to prospect theory is presented more fully in Chapter 2.
15. *Risk* referred to exposure to or potential for danger or injury (Adams, 2014). In the context of the current study, risk is defined as exposure to danger that could harm or damage an individual or cargo.
16. *Riskiness* is defined as the level of risk (Adams, 2014). In the context of the current study, risk is associated with the decision outcome, specifically whether a participant selects a risk-averse decision outcome or risk-seeking decision outcome.
17. *Risk-averse decision outcome* referred to as an individual's preference for certainty over uncertainty (Lovallo & Ketencioglu, 2016). In the context of the current study, participants choice to return to the departure site, as indicated by their response to the dichotomous decision outcome measure, and by their indication on the agreement

scale of agree to return to the departure site (2) or highly agree to return to the departure site (1).

18. *Risk propensity* is defined as an individual's willingness to take risk (Sitkin & Pablo, 1992). The current study measured risk propensity using the risk propensity scale, and risk propensity was included as a potential covariate.
19. *Risk-Seeking decision outcome* referred to as an individual's preference for uncertainty over certainty (Lovallo & Ketencioglu, 2016). In the context of the current study, it was defined as a participant's choice to continue to the departure site, as indicated by their response to the dichotomous decision outcome measure, and by their indication on the agreement scale of agree to continue (4) or highly agree to continue (5).
20. *Type of flight experience* is the aircraft a pilot has or currently flies. In the context of the current study, a one-item researcher-developed, self-reported question that asked participants to "select all that apply" with the following 4-point multiple-select options: manned aircraft (not helicopter, helicopter, UAS, and none.
21. *UAM* is an acronym for urban air mobility, an aviation transportation system that will use highly automated aircraft that will operate and

transport passengers or cargo at lower altitudes within urban and suburban areas (Cokorilo, 2020). In the context of the current study, to simulate UAM the participant flew a remotely-piloted eVTOL aircraft in an urban area at altitudes between 600 AGL and 3000 AGL.

22. *UAM class experience* is whether an individual has taken the Florida Tech course that covered UAM. In the context of the study, participants were presented a researcher-developed one-item question asking, "Have you taken the Urban Air Mobility Ecosystem: AVT 5201-W01 course at Florida Tech?" with dichotomous response options of yes or no.
23. *UAS* is an acronym for unmanned aircraft system, "a remotely-piloted aircraft and its associated elements required for the operation of the unmanned aircraft in the national airspace system" (ICAO, 2011, p.12). In the context of the current study, the accessible population included students who had participated in a UAS course at Florida Tech or individuals who were part of HAI or NAFI and anyone in the community with UAS experience.
24. *UAS Experience* is a one-item researcher-developed, self-report question asking participants, "What level of experience do you have flying UAS?" with the following 5-point multiple-choice options: None, less

than 1 year, 1 year to less than 3 years, 3 years to less than 5 years, and 5 years or more.

25. *Utility* is the degree to which an individual experiences satisfaction or dissatisfaction (disutility) associated with a decision outcome (Wickens et al., 2017). In the context of the current study, utility was manipulated using payload. Specifically, whether or not there was a human onboard the aircraft or solely cargo. Decision outcomes associated with passengers aboard the aircraft were expected to hold higher levels of utility compared to cargo that was expected to hold low utility.
26. *VFR* is an acronym for visual flight rules, and refers to weather conditions that allow the pilot to see outside the aircraft (FAA, 2015). In the context of the study VFR referred to a flight in clear weather conditions acceptable for UAM flight.
27. *Video game experience* is defined as the length of time an individual has been playing video games. In the context of the study, a one-item researcher-developed, self-report question asking participants, “What level of experience do you have playing video games?” with the following 4-point multiple-choice options: Less than 1 year, 1 year to less than 3 years, 3 years to less than 5 years, 5 years or more.

28. *Video Game Frequency* is defined as how often an individual plays video games (Wood et al., 2007). In the context of the current study, an individual's response to a one-item researcher-developed, self-report question asking, "How frequently do you play video games?" with the following four-point multiple-choice options: Daily, Weekly, Monthly, Yearly, and Never.
29. *Weather-related decision-making* referred to as when pilots have to make a decision as to whether or not to press on during a flight into deteriorating weather (Walmsley & Gilbey, 2017). In the context of the current study, defined as a participants' choice between continuing to the destination site or returning to the departure site based on the weather conditions in the scenario.
30. *Workload* is defined as the level of demand on human cognitive processes relative to the human's capacity for collecting and processing information (Moray, 1979). In the context of the current study, mental workload was captured using the NASA-Task Load Index (NASA-TLX) and served as a covariate.

Research Questions and Hypotheses

The following section covers the three research questions that guided the current study and the associated hypotheses.

Research Questions

Research Question 1. What is the effect of payload on the riskiness of weather-related decision-making?

Research Question 2. What is the effect of framing on the riskiness of weather-related decision-making?

Research Question 3. What is the interaction between payload type and framing for riskiness of weather-related decision-making?

Research Hypotheses

The corresponding research hypotheses were as follows:

Hypothesis 1a. Independent of frame-type, passenger payloads will result in higher frequencies of "continue to destination site," considered a risk-seeking decision outcome, as indicated by the categorical measure of decision outcomes, compared to cargo payloads.

Hypothesis 1b. Independent of frame-type, passenger payloads will result in participants characterizing their continuous decision outcomes as being more in agreement with continuing to destination site, considered a risk-seeking decision outcome, compared to cargo payloads.

Hypothesis 1c. Independent of frame-type, passenger payloads will result in lower decision times than cargo payloads.

Hypothesis 2a. Independent of payload type, gain frames will result in higher frequencies of "return to departure site," considered a more risk-averse decision outcome, than no frames, which will result in higher frequencies of "return to departure site," than loss frames.

Hypothesis 2b. Independent of payload type, gain frames will result in participants characterizing their decision outcomes as being more in agreement with returning to the departure site than no frames, which will result in participants characterizing their decision outcomes as being more in agreement with returning to the departure site than loss frames.

Hypothesis 2c. Independent of payload type, framing will not have an effect on decision times.

Hypothesis 3a. Payload will have a different effect on the level of agreement to continue or return depending on the frame condition.

Hypothesis 3b. Payload will have a different effect on decision time depending on the frame condition.

Study Design

The current study used an experimental design, specifically a within groups 2 (human vs. cargo) by 3 (no frame vs. positive frame vs. negative frame) repeated measures design examining impacts on both categorical and continuous measures of decision outcome and decision time. A repeated measures design was appropriate as there was only one group, and each participant was administered all levels of the two independent variables. A repeated measures design helped to control for individual differences among subjects, such as experience or skill levels, as participants served as their own control.

Significance of Study

UAM will create challenges that are novel to pilots and the aviation industry, these challenges are important to overcome to ensure its success (NASA, 2018). The results of the current study help provide insight into the impact of framing on the riskiness of weather-related decision-making in a UAM context. The current study also illuminates how the riskiness of a pilot's weather-related decision-making is impacted by whether there are passengers or cargo onboard. The results of the study could help inform UAM pilots' decision-making training. For example, pilots may need to be made aware of the impact that payload type has on their decision-making process and training may need to be altered depending on the type of payload to compensate for this bias. Additionally, insights into the impacts of framing may provide interface design options that leverage framing to present information to UAM pilots.

Study Limitations and Delimitations

Limitations

Limitations are conditions, events, and circumstances that are beyond the control of the researcher and therefore can affect the generalizability of the study and findings. Limitations of the current study included:

1. Representativeness of the Sample. The sample consisted of Florida Tech students with flight experience or UAS experience, helicopter pilots who were part of HAI due to their knowledge of airspace and experience flying/operating smaller aircraft, pilots who were members of the National Association of Flight Instructors (NAFI), and pilots who were on social media. I did not have control over the experience and prior training of my sample nor what experience is required for future UAM operations. Given that the requirements for future UAM pilots do not currently exist, there may be different training requirements in the future yielding additional differences between the current sample and UAM pilots, limiting the generalizability of the current study.

2. Representativeness of the Selected Vehicle. I did not have control over the vehicles that will be certified for future UAM operations. Therefore, the simulated vehicle used in the study may not be representative of what UAM vehicles are ultimately used, and therefore limit the generalizability of the study's findings. The vehicle selected for the current study was selected based on UAM literature that has emerged thus far and communication with current experts in the field. Therefore, a study which uses a vehicle which is representative of the final vehicle may yield differing results from the current study.

3. Representativeness of Scenarios. As was previously stated, the current study was based on the UAM literature that has emerged thus far and communication with current experts in the field. However, the field is not extant and may not be for the foreseeable future, therefore changes in factors relative to the flight, and departure/destination sites have the potential to change after the study. Therefore, locations of the destination and departures may not be representative of future flights and therefore limited the generalizability of the study's findings. As such, studies that use scenarios once they are finalized may yield different results from the current study.

4. Integrity of Participants' Responses. The measures utilized in the study were self-report and participants may not have been truthful or forthcoming with all of their responses. As such, similar studies that are not self-report and require participants to respond to all questions may yield different results.

Delimitations

Delimitations include constraints on the study that I as the researcher, imposed on the study to improve the feasibility of the study implementation, but that may have impacted the interpretations and generalizability. Delimitations of the current study included:

1. Sampling Strategy. The current study used both convenience sampling and snowball sampling. With respect to convenience sampling, any participant from the accessible population who was willing to participate was included. Additionally, if any participant was willing to identify other individuals matching the requirements, and they believed they would participate in the study they were included. Both sampling strategies were used in hopes of increasing the sample size. However, this sampling method likely resulted in a non-representative sample. If a similar study were conducted using a different sampling strategy, the study may yield different results.

2. Participant Inclusion. The current study removed any participants who did not make a decision for all six scenarios. This was due to the fact that MANOVAs are not robust against missing data and mean computation is not appropriate when large amounts of data are missing. However, this may have led to a biased sample. If a similar study were conducted with more data points where none were excluded, the results could be different from the current study.

3. Study Design. The current study used a repeated measures design to examine how different payloads affected the riskiness of weather-related decision-making when most other variables were held constant. The use of a within-subjects repeated-measures design may, however, have primed participants in their subsequent scenarios when they realized the pattern of the scenarios wherein they would be making a decision to continue or return for similar weather. A similar study using another design such as a between-subjects design, that does not provide the participant with more than one framed scenario or payload may yield different results.

4. The Simulated UAM Aircraft. The UAM aircraft chosen for the current study was selected due to its customizability and inexpensive cost. However, there are other simulated vehicles available for purchase, none of which are more representative of future vehicles than others, as no vehicle has been certified and verified for mass production. However, the interface chosen for the current study may not be representative of the information used in future UAM aircraft as the

UAM space matures. A study that employs a different vehicle may yield different results than the current study.

5. Representativeness of Scenario Challenges. The weather selected in the current study's scenarios did not span the full range of weather challenges UAM pilots may experience. Weather presentation was also done using a table format to reduce the amount of reading time for participants. Therefore, studies which use other weather challenges such as icing conditions or present weather in formats pilots may be more familiar with, such as on a display may yield varying results compared to the current study.

6. Representativeness of the Task Load. The study was presented as video recordings via Qualtrics survey software due to testbed limitations presented in Chapter 3. Participants were unable to control the aircraft and instead watched a simulated flight. Although the simulated software allowed for participants to view a high-risk scenario at an appropriate air space, a recording of a simulated flight cannot imitate the true workload, time demands, and environmental stressors that a live UAM flight would impart. Further, the lack of controls or ability for the participants to actively fly the vehicle cannot imitate the true demands of operating an eVTOL vehicle. The use of the survey software led to an inability to control the location where the survey study was completed and may have yielded location effects. Therefore, future studies utilizing a vehicle that can be controlled and in one location may yield differing responses. Additionally, future UAM pilots in a real-world UAM flights may not yield the same responses as they do in the current study, limiting the generalizability of the study.

7. Decision-Making Measures. The current study used two decision-making outcome measures that were selected based on previous studies examining prospect theory. The first was a dichotomous measure with the option to continue to the destination site or return to the departure site. The second was a continuous measure, which included a rating of the level of agreement to continue or return to the departure site. These measures may not cover all aspects of decision-making. Further, the continuous decision outcome measure did not use precise wording. Studies that use a differing continuous scale such as confidence scale may yield different results.

8. Time Measure. The current study measured the decision time for all six scenarios. However, the length of the decision options may have led to a difference in decision times, resulting in an inability to accurately interpret effects of framing and payload on decision time.

9. Representativeness of Decision Options. The current study utilized information from the literature in the UAM field and experts to create decision options that may not represent the full array of options or information typically available to pilots. For example, in real-life, a pilot may decide not to continue to the destination location or return to the departure site, but rather decide to divert to an alternate site or change altitudes, alternatives that were not be included in the current study. Therefore, studies that include the option to divert or change altitude may yield differing results from the current study. A study that uses different or additional information within the decision options could result in other decision outcomes for the pilot.

10. Counterbalancing. The current study utilized counterbalancing to account for the anchoring that can be experienced by the type of the payload. Therefore, studies that do not use counterbalancing and employ other methods such as randomization may yield different results than the current study.

11. Data Collection Issues. The current study was unable to collect data pertaining to whether participants actually clicked in and viewed the video on Qualtrics. Therefore, studies that include a feature that allows the researcher to know whether the participant watched the simulated video might yield different results than the current study.

Chapter 2

Literature Review

Introduction

This chapter is organized into three main sections. The first section presents information about the theoretical foundation in which the current study was grounded, specifically, prospect theory (Kahneman & Tversky, 1979). The second section provides a review of past research related to prospect theory and how it impacts decision-making. The chapter concludes with a summary of the related literature and a discussion of its implications to the current study.

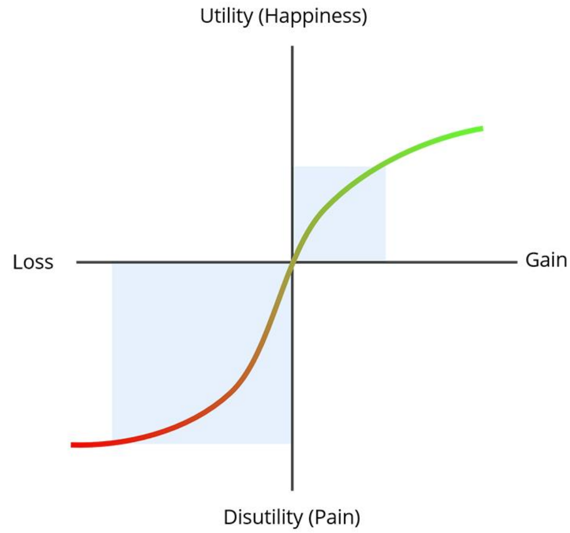
Overview of Underlying Theory

Prospect Theory

Prospect theory is a behavioral model developed by Kahneman and Tversky (1979) that explains how people decide between alternatives that involve risk and uncertainty using the likelihood of gains or losses. Individuals weigh decisions in terms of gains or losses and assign values to risky prospects based on the subjective value (i.e., utility) of a potential outcome. For example, if an individual is given the option to partake in a raffle where there is a 50% chance of winning $10 and 50% chance of losing $10. They focus on the potential utility associated with the gain of $10 and disutility with the loss of the $10 (Wickens et al., 2017). Another aspect of prospect theory is diminishing sensitivity or diminishing marginal utility. Diminishing marginal utility explains how people think in terms of expected utility relative to a reference point (e.g., current wealth) rather than absolute outcomes. For example, the amount of change in utility experienced from $5 to $100 is much more than the change in utility from $505 to $600, even though the difference between both values is $95. Diminishing marginal utility can be seen in Kahneman and Tversky's value function (see Figure 2.1). The value function is a key means of illustrating prospect theory, in which the X axis represents the objective value or true value of a gain or loss and the Y axis represents perceived utility or the subjective value that individuals assign to expected outcomes. In Figure 2.1, diminishing marginal utility is apparent in that although subjective utility increases with movement away from the X axis, the impact of the change in value decreases. For the X axis, movement farther from the Y axis, represents an increase in the objective value (e.g., to the right could be a financial gain from $100 to $500; to the left could be from a financial loss of $100 to $500). For the Y axis, movement farther from the X axis, thought of as their reference point, represents an increase in an individual's subjective utility.

Figure 2.1

Kahneman and Tversky's (1979) Prospect Theory Value Function



Note. The horizontal axis represents the objective value and the vertical axis represents the subjective utility.

Gains vs. Losses. In the value function, which describes the hypothetical relationship between objective value and subjective utility, concavity is present for gains, contributing to risk-aversion for gains, whereas convexity is present for losses, contributing to risk-seeking for losses (Fox & Poldrack, 2009). Furthermore, there is a steeper initial slope to the left of the vertical axis (loss) compared to the initial slope of the line to the right of the vertical axis (gain). This indicates that losses are more concerning or felt more deeply by individuals compared to gains, a consistent finding in prospect theory. Generally, gains are weighted less than losses (Tversky & Kahneman, 1992). Individuals are typically more risk-averse for gains (i.e., unwilling to partake in risk to obtain gain) and risk-seeking for losses (i.e., willing to take a risk to avoid a loss). This is proposed to be due to the perceived consequences of a loss being felt more deeply (weighted more severely) than the perceived consequences of gain (Kahneman, 2011; Wickens et al., 2017). The slope of the value function also decreases with movement away from the origin. This indicates diminishing perceived utility for both gains and losses (see Figure 2.1.)

In the context of the current study, the risky weather-related decision was whether to continue to the destination site although potentially poor weather conditions or return to the departure site. Pilots were expected to assign a perceived utility, or subjective value, to the decision options based on (a) gains associated with a successful and on-time arrival, and the safety and comfort of passengers and/or cargo onboard; and (b) losses associated with a late or no arrival, passenger sickness/discomfort or damaged cargo due to turbulence, and injured passengers and damage/loss of the aircraft and human life due to an accident. It was hypothesized that an equivalent objective loss (e.g., an accident) will have a higher negative utility for a passenger-carrying flight when compared to a cargo-carrying flight, due to greater perceived value of human life.

Certainty and Prospect Theory. Prospect theory also explains how people are not accurate in their probability estimates and illuminates how there is an interaction between probabilities and the shape of the value function for gains and losses (Gonzalez & Wu, 1999; Kahneman & Tversky, 1979). In general, individuals are risk-seeking for both gains with low probabilities and losses with high probabilities, but risk-averse for gains with high probabilities and losses with low probabilities (Gonzalez & Wu, 1999; Prietzel, 2020). This is referred to as the fourfold pattern of risk attitudes (Tverksy & Kahneman, 1992). Individuals prefer to side with options that produce certainty in gain-framed scenarios (Wickens et al., 2017). A sure gain is preferred to a probable one, however, a probable loss is preferred to a sure loss (Jou et al., 1996; Kühberger, 1998). An example of a sure gain being preferred over a probable gain in the context of the current study, would be the choice between Option A: Returning to the departure site, which will ensure passengers are safe, the pilot's record is not tarnished, and the aircraft is safe, and Option B: Continuing the flight, in which the chances of the passengers and aircraft arriving safely, with an untarnished record are uncertain. Prospect theory predicts that, when framed in this way, the pilot would choose Option A, and turn around and return to the departure site. An example of a possible loss being preferred over a certain loss, in the context of the study, would be the choice between Option A: Returning to the departure site, which will ensure the passengers are late, put the pilot's job at risk, and ensure unhappy passengers, and Option B: Continuing the flight, in which the chances of late arrival, job loss, and unhappy passengers are uncertain. In this scenario, prospect theory predicts that loss aversion will occur and the UAM pilot will likely be risk-seeking and continue to the destination site. However, an individual's inaccurate probability estimates can lead to situations in which losses produce risk-aversion and gains produce risk-seeking.

Framing. Prospect theory can be used to influence individuals' decision-making, by providing information that highlights gains or losses (Winskel et al., 2016) . This integral feature of the prospect theory is known as the framing effect, sometimes referred to as framing bias, which accounts for how an individuals' preference for a decision option changes as a function of how the decision outcome is presented (Sher & McKenzie, 2006; Tversky & Kahneman, 1981; Wickens et al., 2017). For example, in its simplest form, consumers are more likely to purchase a piece of steak that is labeled 80% lean over one that is labeled 20% fat. This is because framing the same meat in terms of its leanness is a positive frame of reference; however, framing the meat in terms of fattiness is a negative frame of reference. Therefore, changing the frame of reference or neutral point, by presenting the same information as a loss or a gain, can alter decision outcomes.

Framing both options in terms of what the individual has to gain will change the frame of reference compared to both options being framed in terms of what the individual stands to lose. If a scenario is framed in terms of potential losses, individuals are more likely to make a decision consistent with risk-seeking to avoid a loss. For example, in the context of the current study, if the pilot is presented the following information halfway to his or her destination: (a) return to the departure site, where late passengers will cause the company to have to cancel or reschedule passengers, this will impact the rest of the flights along your route, and the pilot's company will be disappointed in the inability to stay on schedule, or (b) continue to the destination site, where the chance that the flight conditions are unsafe for landing and that the conditions cause passengers to get hurt is unlikely. Despite the risk of an accident, the pilot is more likely to select the latter option and continue to the destination, as the scenario is framed in a way that highlights potential losses, which individual's will try to avoid. However, if the same scenario is framed in terms of gains, the individual would be more likely to avoid taking a risk and go for the sure gain. For example, if the pilot is instead given the options to (a) return to the departure site, which will ensure the aircraft is safe, passengers are unharmed, and passengers and company will recognize the pilot's commitment to the safety, or (b) continue to the destination, where the chances of a safe on-time arrival for the passengers aboard the aircraft although uncertain, is likely, the passengers' expectations will be met, and the pilot's exemplary record for meeting passenger transportation demands will continue. Prospect theory illuminates how using differing frames to express the same information can lead to marked differences in decision-making. This can be attributed to the aversion people have to losses, which is consistently found in decision-making (Kahneman & Tversky, 1979). This has been shown in studies across industries, including the aviation industry wherein positive/negative framing has had an effect on weather-related decision-making (O'Hare & Smitheram, 1995; Walmsley & Gilbey, 2020).

Review of Past Research Studies

Prospect theory has been used to study a range of different research questions such as whether prospect theory's diminishing sensitivity influences airline ticket purchases (Nicolau, 2011) or whether an individual's probability assessment is influential in economic and application design decisions (Barberis, 2013). However, this review of literature focused on studies examining two specific research areas related to the influence of prospect theory in decision-making: (a) the impact of manipulating utility on decision-making, and (b) the impact of framing on decision-making. Specifically, studies that have manipulated characteristics of the potential decision outcome, such as whether a decision outcome leads to a loss of human life versus a financial loss were included. Additionally, studies that examined the impact of framing on decision-making were reviewed. For example, studies that examined the impact on decision-making based on whether an outcome was framed in a positive frame (e.g., purchasing life insurance will ensure your family is taken care of) versus a negative frame (e.g., purchasing insurance will add an additional cost of $600 per month). I begin by presenting studies conducted in a non-aviation context followed by studies that examined these phenomena in the field of aviation.

Non-Aviation Studies Using Prospect Theory

A range of studies have examined the impact of utility and framing on decision-making (Barberis, 2013; Fagley & Miller, 1997; Ronnlund et al., 2005). This section begins by presenting studies that have examined only framing or utility, followed by those that examined at both.

Abdellaoui et al. (2013) examined the impact of prospect theory outside of the lab, specifically the phenomena of framing, loss aversion, utility curvature, and probability weighting. For the purposes of the current study the focus was on the methods and results associated with framing. Snowball sampling was used to recruit 46 (9 female, 37 male) financial professionals consisting of private bankers and fund managers. The financial professionals were asked to partake in a 30-minute computer-run experiment. The experiment asked them to make binary choices presented as options on a pie chart with the sizes of the probabilities corresponding with the areas in the pie charts. Each participant received 11 loss frames and eight gain frames. Choices represented investment opportunities and monetary amounts represented the company's money. The first two initial choices had equal expected values. For example, Prospect A: asked participants to make a choice between a 67% chance of losing \$600 and a 33% of losing \$1,000 or Prospect B a 33% chance of losing \$2,500 and a 67% chance of losing \$100. The subsequent choice made the chosen prospect less attractive or made the previous un-chosen prospect more attractive. Participant choices were either marked as risk-averse (a response smaller than the expected value of the prospect), risk-seeking (a response greater than the expected value of the prospect), or risk neutral (a response equal to the expected value of the prospect). Results of the study were consistent with a framing effect as risk-aversion was observed for scenarios framed as gains and risk-seeking for scenarios framed as losses. For gains, there were 232 (72%) risk-averse answers, 89 (28%) risk-seeking, and 1 (0.3%) risk neutral, whereas for losses there were 207(41%) risk-averse answers, 295 (58%) risk-seeking, and 4 (0.8%) risk neutral answers. A random effects probit model was used to examine whether there were significant differences between the answers in each frame. The proportion of risk-averse answers was significantly higher than the proportion of risk-seeking and risk neutral answers in gain-framed scenarios (p = .001). The proportion of risk-seeking answers was significantly higher than the proportion of risk-averse and risk neutral answers in loss framed scenarios (p = .040). In the context of the current study, framing information as a gain may lead to risk-aversion and information presented as a loss may lead to risk-seeking.

Guo et al. (2017) were interested in investigating the effect of framing and time pressure on risky decision-making. The sample consisted of 195 university students. The researchers utilized a similar method to Diederich et al. (2020) giving participants a base amount of hypothetical money anywhere between $20 and $90, and subsequently asking them to make decisions that may cause them to lose or gain money. Probability estimates were randomly drawn from a pool of three options for each trial (.28, .42, .56) and decision options were presented on two side-by-side pie charts. The first pie chart presented a sure option (risk-averse) as either a loss or gain, whereas the second presented an uncertain option (risk-seeking). For example, a gain trial would present the first pie chart shaded entirely in one color with a dollar amount, such as $39. This would indicate a 100% chance of keeping $39 (sure option). If the first pie chart put a minus symbol in front of the dollar amount it indicated a sure loss of money. The second pie chart would show the probability of losing and keeping money when selecting that choice. For example, shading 56% of the graph with $70 indicated a 56% chance of keeping

$70, while the rest of the pie chart would be shaded in another color with a minus symbol in front of the $70 indicating a 44% chance of losing the $70. Framing took place on the first pie chart as it was either displaying the amount as either a certain loss or a certain gain.

The experiment was presented on a computer in two blocks, each block had 72 gain frames, 72 loss frames, and 16 catch trials to ensure participants were paying attention. One block included time pressure in which participants had to make the choice in 1,000 milliseconds (ms) whereas the other trials did not provide participants with any time constraints. Participants in the study received university credit for their participation. Participants were first shown the amount of money they were starting with and then presented with their trials. The study was conducted in four variations. In the first variation, presented to 49 of the 195 participants, pie chart wedges were color coded green for keeping the dollar amount and red for losing the dollar amount. Sure options were displayed on the left and uncertain on the right of the screen. In the second variation, presented to 49 out of the 195 participants, the only modification was the removal of the colors. Colors were replaced with light grey and dark grey for keeping or losing money, respectively. The third variation, presented to 53 out of 195 participants, was identical to the first variation, except location of sure and uncertain options were randomized. The final variation also changed the language used from maximize your money to minimize your losses. A 2 (block: time pressure vs. no pressure) x 2 (frame: gain vs. loss) ANOVA was conducted on the probability of selecting the uncertain or risky option. The results of the study revealed a significant effect of frame, $F(1, 194) = 339.39$, $p < .001$, suggesting that participants' decisions varied by frame. Specifically, participants' behavior was consistent with the framing effect as participants chose the uncertain choice more often when the certain choice was a loss in money. Participants chose the certain pie chart more often over the uncertain pie chart when the certain pie chart presented a gain in money. A significant interaction between block and frame, $F(1, 51) = 22.92$, $p < .001$, indicated the framing effect was greater when less time was present. When these findings are applied to the current study, framing information as a gain may lead to risk-aversion and information presented as a loss may lead to risk-seeking.

A study conducted by Druckman (2001) examined framing effects by presenting the Asian disease problem, asking individuals to choose between two programs designed to combat a disease that is expected to kill 600 people. Participants were presented with the Asian disease problem in one of three formats: gain, loss, or both. The sample consisted of 320 student participants from an undisclosed university who were randomly assigned to one of three groups corresponding to the three framing formats. Group 1 received gain-framed scenarios that highlighted survival. Group 2 received loss-framed scenarios in which outcomes focused on mortality. Group 3 received both scenarios with both types of framing. For example:

> Group 1: If program A is adopted, 200 people will be saved. If Program B is adopted, there is a one-third probability that 600 people will be saved, and a two-thirds probability that no people will be saved.
>
> Group 2: If program A is adopted, 400 people will die. If Program B is adopted there is a one-third probability that nobody will die, and a two-thirds probability that 600 people will die.
>
> Group 3: If Program A is adopted, 200 people will be saved and 400 people will die. If Program B is adopted, there is a one-third probability that 600 people will be saved and nobody will die, and a two-thirds probability that no people will be saved and 600 people will die (Druckman, 2001, p. 92).

Group 3, which received both frames was intended to represent no-frame, that is, the participant's natural or neutral frame. The expectation being that any effect of framing would be cancelled out due to the inclusion of both types of framing. Findings comparing gain and loss groups were consistent with prospect theory. Participants who received gain-framed scenarios in which the focus was on lives saved, selected the risk-averse choice 68% of the time. Participants who received the loss-framed scenarios, highlighting lives lost, chose the risk-seeking choice 77% of the time. A difference of proportions test found this to be statistically significant ($z = 5.54$, $p < .01$). When examining the group that received both framing formats in the decision problem, no significant differences between whether participants chose the risk-seeking or risk-averse decision was found. However, a slight trend towards risk-seeking was found as 56.4% of participants responded in a risk-seeking manner, whereas 43.6% of participants responded in a risk-averse manner. The authors believe that rather than individuals having a neutral frame, individuals may potentially have framing preferences that impact their decision choices. However, given that losses are weighted more heavily than gains (Kahneman & Tversky, 1979; Wickens et al., 2017), it may be that if all frames are presented, individuals would be influenced more by the loss frame and respond in a risk-seeking manner. In the current study, a similar method was used in which participants received a no frame condition. However, the "no frame" condition was void of framing. All participants were first provided with a scenario and asked to make a decision as to whether to continue or divert at their current phase of flight, without highlighting gains or losses.

Roszkowski and Snelbecker (1990) were interested in how utility and framing affected decisions made by financial professionals who deal with financial risk on a daily basis. A sample of 212 financial professionals participated in an adapted version of the Asian disease scenario developed by Kahneman and Tversky (1979). Decision makers were presented with one financial problem asking them to make a decision on an investment strategy to save either their own or their client's money, framed either in a negative or positive light. The adaptation to the scenario changed the decision outcome characteristics from human lives to dollars so as to make it relevant to financial professionals. The scenario was constructed around an investment in the stock market during a downturn in the economy. All participants were asked to complete a survey asking them to report their age, sex, and years of experience and to complete one scenario. Participants could receive the scenario in one of four possible forms: their own money and gain framing, their own money and loss framing, a client's money and gain framing, and a client's money and loss framing. Ownership was manipulated by wording the scenarios in terms of the client's money in one scenario and in terms of the participants' own money in the second instance. Gain frames highlighted money that could be saved while loss frames highlighted money that could be lost. For example, a scenario dealing with a client's money in a gain frame stated the following:

> Imagine that your client has $6000 invested in the stock market. A downturn in the economy is occurring. You have two investment strategies that you can recommend under the existing circumstances to preserve your client's capital. In Strategy A, $2,000 of your client's investment will be saved. In Strategy B, there is a one-third probability that the entire $6000 will be saved, and a two-thirds probability that none of the principal will be saved. Given this information, which of these two strategies would you favor? (Roszkowski & Snelbecker, 1990, p. 7)

In loss framed scenarios, the options were as follows:

> If strategy A is followed, $4000 of your client's money will be lost. If strategy B is followed, there is a one-third probability that nothing will be lost, and a two-thirds probability that the $6000 will be lost (Roszkowski & Snelbecker, 1990, p. 8)

Participants were instructed to place a checkmark in front of their choice after reading the scenario options. An ANOVA was conducted examining the impact of frames (gain versus loss) and ownership (own money versus client's money) on their decision (risk-seeking versus risk-averse). The main effect of framing was significant, $F(1, 211) = 7.43$, $p = .007$, indicating that participants' decisions varied across framing scenarios. Aligning with prospect theory, when participants received scenarios framed in terms of gains, they more commonly picked the risk-averse choice (49 out of 87 participants, 56%). Scenarios framed as losses, led to more risk-seeking choices (89 out of 125 participants, 71%). The main effect of ownership was also significant, $F(1, 211) = 5.91$, $p = .016$, indicating that participants' decisions varied across ownership types. When examining the frequency of decisions by ownership, in scenarios with the money being owned by the participants, more participants chose the uncertain or risky choice (81 out of 123 participants, 66%). Participants whose decision was being made for a client's money, chose the certain or risk-averse choice more (46 out of 89 participants, 52%) than the uncertain/risky choice. Interestingly, when examining the interaction, loss-framed scenarios had higher framing effects, that is a higher percentage of participants chose to respond with an uncertain risky decision, when their own money was in question (77%) compared to those who received a loss scenario with a client's money in question (62%). When examining framing effects for gain-framed scenarios, framing effects were higher or a higher percentage of participants chose to respond with a risk-averse decision when they received a loss scenario with a client's money in question (60%) compared to their own money in question (53%). In the context of the current study, presenting information in a gain frame may yield risk-averse decisions whereas information presented in a loss frame may yield risk-seeking decisions. Furthermore, if participants assign higher utility to human lives than payload, they may respond in a risk-seeking manner more for humans than payload. Finally, when examining the interaction between framing and payload, framing effects were expected to be stronger for the lower utility payload in gain-framed scenarios and stronger for higher utility payload in the loss-framed scenarios. That is, in gain-framed scenarios, participants were expected to be more risk-averse with cargo and in loss-framed scenarios participants were expected to be more risk-seeking for humans onboard than payload.

Diederich et al. (2020) were interested in how framing with sure and uncertain options, needs (i.e., related to utility), and time affected decision-making. Needs were defined as how grave the impacts of losses and gains were. Nineteen undergraduate university participants were asked to choose between two options (a sure option and an uncertain option) presented in either a loss or gain frame. Participants performed test trials with four base point amounts (25, 50, 75, and 100), representing the amount of points a participant started the study with, and four probabilities, selected to serve as the probability of winning the gamble (0.3%, 0.4%, 0.6%, and 0.7%). These were paired to form 16 unique gambles. From these pairs, the sure option for each trial was created to match the expected value of the gamble, depending on framing. For example, an individual with an initial amount of 100 points and a winning probability of 0.7% would have a sure option gain frame of *Keep 70* or a loss frame of *Lose 30.* The gamble is identical, that is both options in the previous example have the same expected value. Participants were also presented with eight catch trials that had non-equivalent sure and gamble options in which one option had a significantly larger expected value (e.g., an individual with an initial amount of 100 points and a winning probability of 0.7% would have a sure option gain frame of *Keep 90* or a loss frame of *Lose 10*). The eight catch trials consisted of four gain frame trials and four loss frame trials. Initial starting values for these trials were also 25, 50, 75 and 100; the winning gamble probabilities were 0.3% and 0.7%. In half of these trials, the sure option had a higher expected value, while in the other half of the trials, the gamble option had a higher expected value resulting in 40 unique games (16 gain frame test games; 16 loss frame test games; 4 gain frame catch games; 4 loss frame catch games). Researchers randomized the order of each game's presentation within each block resulting in 80 trials per experimental block. Four blocks were present in each session, participants received three sessions across three different days leading to 960 observations. Participants could win as much as 5,000 points if they won every gamble.

Time and need were also manipulated. Time was manipulated by participants receiving a time limit of either 1 or 3 seconds in each experimental block. Needs were manipulated by changing the minimum points the participants needed to obtain during one block of trials being 0 points, 2,500 points, and 3,500 points. These needs were presented at three different points in the study. If the need was not met the participant did not pass the trial. The study was presented on a laptop computer and options were shown as a pie chart with the probability numbers. The data were analyzed using descriptive statistics and cluster analyses. For the purposes of the current study the results will focus on framing and needs, which represents a utility manipulation. The results of the study support framing effects as participants presented with loss frames chose the risky option more often (72%) compared to the gain frame (52%). With respect to needs, the participants chose the risky option more often (66%) when need was high, that is they needed more points (3,500 points) to continue, compared to when the needs were low or moderate (when the need was 0 only 61% chose the higher risk and when the need was 2,500 points only 60% chose the higher risk option). Therefore, when utility was high participants took more risk whereas when utility was low, they were more risk-averse. When applying these findings in the context of the current study, gain-framed information may lead to risk-aversion and loss-framed information may lead to risk-seeking. Additionally, a payload of passengers would lead to more risk-seeking decisions compared to cargo due to the higher utility they were expected to hold.

Souza et al. (2020) examined how limited framed information presented to both an operator of a search and rescue mission and a Mars sampling mission affected decision-making. Twenty graduate students volunteered to participate in the study. Framing, probability, and utility were manipulated; however, framing and utility will be the focus of the following section. Framing was manipulated using the wording of “good” and “bad” for the Mars scenario, as well as “useful” and “wasted” in the earthquake scenario. Utility was manipulated using either human lives in the earthquake scenarios versus rock quality in the Mars scenario. Participants were either (a) helping victims of an earthquake or (b) collecting rocks on Mars. In the earthquake scenario the idea was to help eight known victims trapped beneath the rubble using three drones to localize the victims and deliver eight available first-aid kits. A guideline was presented to find and deliver a first-aid kit to the maximum number of victims within a certain amount of time. For the Mars rock-sampling scenario, participants were asked to use three drones to locate and collect eight different types of rocks with the goal of returning to Earth in a capsule with eight good rocks within a certain amount of time.

Participants were first presented with a training mission and then randomly executed 10 missions (repetitions) for a given scenario, each approximately 3 minutes long. When the drones found something during the mission, 10 different pre-formulated sentences, including framing and different probabilities, were randomly presented. The operator was told that something had been detected and decided between either keeping or releasing a kit in the earthquake scenario and keeping or releasing a rock in the Mars scenario. Sentences were either framed positively, that is as a gain, or negatively, as a loss. In the earthquake scenario, an example of a positively framed sentence is: there is a 60% chance that the kit will be useful (meaning it would reach the victim), whereas a negative (loss) frame would be, there is a 40% chance that the kit will be wasted (i.e., not reach the victim). In the Mars rock sampling scenario, an example of a positive (gain) frame is a sentence such as: There is a 60% chance of a good rock; and loss frame: There is 40% chance of a bad rock. The message then asked if they wanted to release the kit or rock, depending on the scenario and participants chose between yes or no. Participants were given 10 seconds to decide, any answers not provided in the time period were considered a no.

The researchers reported that participants were found to favor uncertain gains when they faced positive framing, selecting to release a kit and save lives in the earthquake scenario or keep a rock in the Mars scenario. When losses or negative framing was used, participants chose to select the risk-averse decision by keeping the kit (not risking sending a kit that would not reach a victim) and releasing the rock (not keeping a rock they were uncertain of). These findings do not align with prospect theory as with a gain frame people are typically risk-averse so it would have been expected that they would not be willing to take the risk and would have kept the kit and released the rock. It would be expected that those in loss frames participants would try to minimize losses and select to release a kit and keep a rock more than to keep a kit and release a rock. However, unlike traditional framing, Souza et al. (2020) only presented half of the framed information, which likely affected decision makers. Kahneman and Tversky (1979) frame both parts of an outcome rather than one, such as, "There is a probability of 60% that a kit will be wasted, and a 40% chance that a kit will not be wasted. Rather than only including that there is a probability of 60% that a kit will be wasted." When examining the differences in decisions between both scenarios as they would be expected to have different utility values, prospect theory held true. Those in the earthquake scenario selected the uncertain/risky choice of releasing a kit more than they chose the uncertain/risky choice of keeping a rock in the Mars scenario. Prospect theory would predict that if human lives have a higher utility than Martian rocks, people would be more risk-seeking attempting to avoid losses and select yes to release a kit more often in the earthquake scenario and no to hold onto the rock in the Mars scenario, to avoid a loss. In the current study framing was presented in the manner used by Kahneman and Tversky (1979). Additionally, it is expected that similar findings will result with respect to utility. Participants would be expected to respond with more risk-seeking in human life scenarios and more risk-aversion with those in which cargo are onboard.

Zhou et al. (2021) examined the impact of different presentations of framing on decision-making in three different studies. The aspects of the study related to the framing presentation used by Kahneman and Tversky (1979) are presented. Within the first study 1,119 participants' decision-making was examined in four different scenarios of varying utility: the fish kidney disease, water contamination, genetically engineered crops, and endangered forest. For the fish-kidney-disease scenario, participants were asked to imagine they were a government official in an adjacent village where fish species were dying. They were provided with options that would lead fish species to be saved or die. The water contamination scenario asked participants to imagine that they are a medical expert asked to share the medical option they would prefer to use to combat a disease contaminating the water due to a refinery leak. Choices focus on children's lives lost or saved by drug options. The endangered forest scenario asked participants to imagine that an endangered forest was at risk, and they had to choose between two options that could lead to acres of an endangered forest being lost or saved. The authors did not include any descriptive information on the engineered crops scenario. The study consisted of three experiments, the first included the four different scenarios, the second and third experiment only utilized the water contamination scenario.

Participants were given one of the four scenarios described in the previous paragraph. In each scenario participants were presented with choice options and asked to choose between a sure and a risky option for that situation. An example of a scenario in which there was a sure gain presented is: “If the release of the fish is implemented 4 fish species will survive, and 7 will not survive.” An example of a risky gain that could involve no gain is: “If the release of fish is implemented, there is a two-third probability that all of the 12 fish species will survive, and there is a one-third probability that none of the 12 fish species will survive” (Zhou et al., 2021, p. 403). An example of a risky loss that may yield no loss is: “If the release of fish is implemented, there is a two-third probability that all of the 12 fish species will die, and there is a one-third probability that none of the 12 fish species will die” (Zhou et al., 2021, p. 403). The same choice options as the fish scenario were used for all other scenarios except they were replaced with children's lives, acreage amount, or fish lives. In the second study, 900 participants were utilized and only the water contamination scenario was utilized. The study extended the first study by setting different probabilities of risky options to examine the original effect under various probability conditions. Probabilities of 25%, 47% and 72% were used and the fish were changed to 10 children. In Study 3, 920 participants were utilized and the only changes between Study 2 to Study 3 were the addition of two conditions wherein either the certain or the risky option had a larger expected value. Instead of 10 children, the number of children increased to 32, 40, or 48 children, manipulating utility using more lives. In each scenario, the participants were presented with a description of a scenario and then asked to choose between a sure and a risky option for that situation. Demographic information on age, sex, education, and residence was collected.

For the first study, an ANOVA was conducted with framing and task type as between-subject factors and the scenario as a within-subject factor. The main effect of the scenario, that is whether they received the fish kidney disease, water contamination, genetically engineered crops, or endangered forest, was significant, $F(3, 3339) = 4.45$, $p = .004$, indicating preference for the risky choice varied across the scenarios. When examining the means, the water contamination scenario wherein children's lives were at risk had a higher probability of risky choices under the negative frame (0.74) compared to the genetically engineered crops (0.62), fish kidney disease (0.67), and endangered forest (0.56). The researchers did not clarify whether the genetically engineered crops led to lost lives or lost crops. However, when examining the other three findings, those aligned with prospect theory as children's lives would be expected to hold higher utility compared to acreage and fish lives. Therefore, it would be expected that higher risk taking would result as participants would be willing to take risks to avoid a loss, leading to risk-seeking behavior more than the other two scenarios dealing with fish and acreage, consistent with the findings. Additionally, it would be expected that animal lives would hold higher utility than that of plants and lead to higher risk taking to avoid a loss. Partially consistent with the expectation, in terms of gain frames and examining means across scenarios, risk-aversion was highest for the endangered forest, however, human lives did not yield the lowest risk-aversion but rather fish lives. The endangered forest scenario wherein acres of forest were at risk had the higher risk-averse behavior (59%), followed by the water contamination scenario with human lives (57%), and finally the fish kidney disease with fish lives (52%).

The main effect of framing was found to be significant $F(1, 1113) = 116.34$, $p < .001$, supporting that there was a greater preference for selecting the risk-seeking option under the loss frame than under the gain frame. With respect to framing in experiment one, participants who received scenarios in a loss frames chose the risky losses more often than the sure loss (65%). Those who received gain-framed scenarios chose the sure gain, that is the risk-averse choice, more often than the risky gains (56%). The interaction between scenario and framing was also significant, $F(3, 3339) = .40$, $p = .017$, indicating that across scenarios the size of the framing effect varied. Framing effects were largest for the water contamination scenario, using lives and followed by the fish kidney disease using fish lives, and finally the endangered forest scenario which impacted the environment. When examining the framing effects by scenario, the water contamination scenario had stronger framing effects when the scenario was framed as a loss compared to a gain (74% compared to 57%, respectively). That is, more participants were risk-seeking in the loss framed scenarios than they were risk-averse in the gain-framed scenarios. A similar trend emerged in the fish kidney disease scenario, as loss framed scenarios had stronger framing effects when the scenario was framed as a loss compared to a gain (67% compared to 52%, respectively). The endangered forest scenario did not trend towards as large of a discrepancy between framing effects as the other two scenarios (56% compared to 59%, respectively). Additionally, in the endangered forest scenario, the framing effect was slightly higher when the scenario was gain framed compared to loss framed. This may point to an interaction, that is, framing effects may be stronger for higher utility outcomes in loss-framed scenarios while in gain-framed scenarios lower utility outcomes yield higher framing effects. However, contrary to the expected interaction, human lives yielded higher framing effects than fish lives in the gain-framed scenarios.

The second study, in which manipulation occurred for three different probability estimates in addition to framing, yielded similar results as Study 1. An ANOVA was conducted with framing and task type as between-subject factors and probability as the within-subject factor. The main effect of framing was found to be significant, $F(1, 886) = 130.79$, $p < .001$, supporting higher risk-seeking for scenarios framed as losses compared to those framed as gains. Those who received loss-framed scenarios chose the risk-seeking choice more than 70% of the time across all probabilities (77%, 75%, 76%) while those who received scenarios framed in terms of gain more commonly chose the risk-averse outcome in two (25% and 47% probability but not 72% probability) out of three of the probability estimates (54%, 52%, 43%, respectively). In this second study framing effects were present for the first two of the scenarios and not for the final scenario in the gain frame. This is likely due to the increase in utility leading to stronger loss aversion as people are more concerned with a greater loss in utility than they appreciate a gain even of the same amount (Wickens et al., 2017). As in the third version of the scenario used for the second study, participants chose the risky option of 25% chance that the health of all 40 children will be saved over the certainty that 10 children will be saved, as the certain loss of 30 children is too high in utility.

The third study, in which manipulation occurred for the expected value/utility (that is, by increasing the number of children) in addition to framing, also yielded significant effects. An ANOVA was conducted with framing and task type as between-subject factors and probability as the within-subject factor. The main effect of framing was found to be significant, $F(1, 900) = 121.72$, $p < .001$, once again supporting higher risk-seeking for scenarios framed as losses compared to those framed as gains. Those who received loss-framed scenarios chose the risk-seeking choice more than 60% of the time across all three scenarios (70%, 63%, 70%). Those who received scenarios framed in terms of gain more commonly chose the risk-averse outcome compared to the risk-seeking choice in one (32 children but not 40 children or 48 children) out of the three scenarios (56%, 51%, 50%, respectively).

When examining the impact of the amount of children or event ratio as a manipulation of utility, the findings were not consistent with prospect theory's expectations. A repeated-measures ANOVA with framing and task type as the between-subject factors and utility as the within-subject factor was conducted. The main effect of utility was not statistically significant $F(2, 1800) = 1.67$, $p = .189$, meaning that as the amount of children used in the framed scenario increased the participants decisions did not change significantly. However, when looking at trends for gain-framed scenarios, as the amount of children in the scenario increased so too did the proportion of risky decisions. In the first scenario, when there were 32 children's lives at stake, 56% of participants chose the risk-averse scenario. When 40 lives were at stake, 51% chose the risk-averse scenario. When 48 lives were at stake, 50% chose the risk-averse choice. When examining the proportion of risk-seeking decisions in the negative-framed scenarios, no trend was apparent. In the scenario with 32 children, 70% of those who received the negatively framed scenario chose the risk-seeking choice, this was also found for the scenario with 48 children. However, in the scenario with 40 children, only 63% chose the risk-seeking decision.

As was mentioned above, in the third study framing effects were present for one of the two scenarios in the gain frame. Much like the second study, this is likely due to the increase in utility leading to stronger loss aversion. Participants chose the risky option of a 25% chance that the health of all children (32, 48 were the number of children's lives) would be saved over the certainty that 10 children would be saved. The certain loss of 22 or 38 children is too high. The small difference in proportions between risk-seeking decisions in loss-framed scenarios may point to the diminishing perceived utility. Utility is already very high with 32 lives and prospect theory explains that the slope of the value function decreases with movement away from the origin. Therefore 32 lives may be close to the tail end of the function and therefore the difference in utility for 40 and 48 is negligible. Whereas if the difference had been between two and 32 lives there may be a larger difference in utility. The difference in utility between human lives, the forest, and fish did, however, yield differences. In the context of the current study, it was expected that passenger lives would yield higher risk-seeking behavior compared to packages, as participants would attempt to minimize losses. The findings relative to framing, lend support for framing effects emerging most of the time, with loss framed scenarios leading to risk-seeking behavior and gain-framed scenarios leading to risk-aversion. However, interaction effects may take place, and framing may be influenced by high utility outcomes (i.e., lives). High utility outcomes may lead to larger framing effects for loss frames and lower framing effects for gain-framed scenarios. Decision outcomes that deal with lower utility, may more commonly yield higher framing effects for gain-framed information. In context of the current study, flights with passengers as payload may yield higher framing effects than cargo in loss-framed scenarios, while flights with cargo as payload may yield higher framing effects than passengers in the gain frame.

Jou et al. (1996) conducted two experiments to examine the effects of framing on decision-making across eight scenarios. The authors additionally examined the role of rationale and reciprocal answers; however, these are not relevant to the current study and will not be discussed. The first study utilized 320 university students while the second used 160 students. The eight scenarios fell into two categories: endangered life and endangered property scenarios corresponding to higher and lower utility, respectively. The endangered life scenarios included: Asian disease, shipwreck, volcanic explosion, and hurricane. In the Asian disease scenario there is an outbreak of an unusual disease, and it is expected to kill 600 people. In the shipwreck scenario a ship hits a water mine in the middle of the ocean and 600 passengers onboard are in danger. In the volcanic explosion scenario a volcano is erupting on a volcanic island in the Pacific Ocean and 600 residents of the island are in danger. In the hurricane scenario a group of small islands in the Caribbean is often ravaged by hurricanes and an estimated 300 people's lives would be in danger in the next hurricane season. In all scenarios, options were presented as two alternatives including a description of the potential outcomes, but void of the choice description. All scenarios except the hurricane scenario presented options as: Option A, if Option A is adopted, 200 lives would be saved or Option B, if Option B is adopted, there is a one-third probability that all 600 lives would be saved, or a two-thirds probability that no lives would be saved. In the hurricane scenario gains were framed as: Option A, if Alternative A is adopted, an estimated 100 lives would be saved in the next hurricane season, and Option B, in which Alternative B is adopted, there is a one-third probability that all 300 lives would be saved, or a two-thirds probability that no lives would be saved in the next hurricane season. In all scenarios, loss-framed choice options were presented as: Option A, if this alternative/option is adopted 400 (300 for the hurricane scenario) people would die or Option B, if this alternative/option is adopted there is a one-third probability that nobody would die and a two-thirds that everybody would die.

The four endangered-property problems involved a shipwreck, renting an apartment, an investment, and selling business assets. In the shipwreck property scenario, a cargo ship hits a water mine in the middle of the ocean jeopardizing 600 boxes of a precious metal. Choice options were presented as gains, with precious metal saved (Option A: 200 boxes would be saved or Option B: a one-third probability that all 600 boxes would be saved and two-thirds probability that none would be saved) or losses (Option A: 400 boxes of the precious metal would be lost or Option B: a one-third probability that no boxes would be lost, and two-thirds probability that all boxes would be lost). In the apartment rental scenario, a person cannot fulfill a signed contract with an apartment manager leaving her $600 deposit in jeopardy. The same choice options were presented as the shipwreck property scenario, however, precious metal is replaced with money he or she would either get back (gain) or lose (loss). In the investment scenario an investment of $60,000 was made in a company whose financial situation is now in jeopardy. Two alternatives are available. Choice options were presented as either gains with amounts the individual would get back (Option A: get back $20,000 or Option B: a one-third probability of getting all the investment back and a two-thirds probability of getting nothing back) or losses (Option A: lose $40,000 or Option B: a one-third probability of losing nothing and a two-thirds probability of losing all the investment). In the asset-selling scenario a chemical company whose assets are worth $240,000 was being forced out of business. Two alternatives for selling the company were presented either framed as a gain (Option A: the owner would recover $80,000 or Option B: a one-third probability that all $240,000 would be recovered and two-thirds probability that zero assets would be recovered) or losses

(Option A: the owner would lose $160,000 or Option B: a one-third probability that zero assets would be lost, and two-thirds probability that all $240,000 would be lost). To discern between the two shipwreck scenarios, the decision outcomes affected would be added to the name, that is Shipwreck (lives) and Shipwreck (property).

In the first study, all scenarios were presented to each participant on separate sheets of paper that were stapled together. Instructions were also provided on a piece of paper that researchers read aloud, asking participants to treat problems as independent from one another. Eight scenarios were utilized, and whether the scenario was a gain or loss framed scenario was randomized. The second study used identical study procedures except that participants were provided a filler question in-between each scenario to distract them from the last scenario. Additionally, at the end they were asked about the total number of lives and properties involved from the scenarios. The only change in instruction was that subjects were told they must complete the test in the order it was given.

With respect to the results of the first study, Categorical Data Modeling (CATMOD) using a log-linear analysis revealed that a main effect of categories (life vs. property) was significant. $\chi^2(l) = 166.24$, $p < .001$. On average, 36% of participants chose the risk-averse decision in the life category, whereas 61% chose the risk-averse decision in the property category. As has been found in other studies, participants made higher-risk decisions when dealing with lives than with property. That is, categories in which human lives were at stake held higher utility leading to higher risk-seeking behavior, whereas the property categories did not yield utility as high as lives, leading to risk-averse behavior.

The main effect of frame was significant $\chi^2(1) = 55.57$, $p < .001$. On average, 58% of participants chose the risk-averse option in the gain-framed scenarios and 41% of participants chose the risk-averse option in the loss-framed scenarios. Consistent with prospect theory, a greater proportion of participants was risk-averse in gain frames while loss frames yielded more risk-seeking responses. Finally, the main effect of scenario was also significant χ^2 $(6) = 19.01$, $p < .001$, suggesting that decisions varied across scenario. That is, risk-averse decisions were different across each of the eight scenarios. Scenario means and percentages were not included in the results, however, a figure showing trends was presented in the work. When examining the trends from highest to lowest risk-aversion using gain framing in scenarios, property was found to have higher risk-aversion than lives. The following order was found: Apartment, Shipwreck (property), Assets, Investment, Disease, Hurricane, Shipwreck (lives), and Volcano. When examining the scenario trends by highest to lowest risk-seeking in loss-framed scenarios, lives trended towards higher risk-seeking than property. The following order was found: Volcano, Disease, Hurricane, Shipwreck (Lives), Shipwreck (Property), Investment, Apartment, and Assets. Lives trended towards higher risk-seeking than property in loss-framed scenarios. Gains trended towards higher framing effects for property scenarios than human lives whereas losses trended towards higher framing effects for human lives than property.

Similar findings emerged in the second study. The main effect of category was significant $\chi^2(1) = 16.99$, $p < .001$ and the main effect of frame was also significant, $\chi^2(1) = 12.25$, $p < .001$. When examining the category means, 29% of participants chose the risk-averse option in the life condition while 62% chose the risk-averse option for the property scenarios. When examining the effects of framing, 59% of those who received the gain frame chose the risk-averse choice, whereas 31% chose the risk-averse choice in loss frame. One potential reason for the higher framing effects found for losses than gains is the weight of losses. Past research has supported that the effects of loss frames linger longer than gain frames (Ledgerwood & Boydstun, 2014). Given that losses are weighted more heavily than gains (Kahneman & Tversky, 1979; Wickens et al., 2017), it may be that if all frames are presented, individuals would be influenced more by the loss frame and respond in a risk-seeking manner thinking more in terms of losses even when presented with a gain.

In the context of the current study, these results suggest that scenarios framed in terms of gains would yield higher risk-averse decision outcomes, whereas scenarios framed in terms of losses would yield higher risk-seeking decision outcomes. When examining utility, if higher utility was assigned to human lives than payload, scenarios in which the decision involves lives would yield more risk-seeking decisions (regardless of frame). Whereas scenarios that involve property were more likely to involve risk-averse decisions. Finally, when examining the interaction between framing and payload, framing effects would be stronger for the lower utility payload (cargo) in gain-framed scenarios and stronger for higher utility payload (humans) in the loss-framed scenarios. That is, in gain-framed scenarios, participants would be more risk-averse for cargo and in loss-framed scenarios participants would be more risk-seeking for humans.

Fagley and Miller (1997) were interested in how varying framing and potential decision outcomes using either human lives or equity affected individual decision-making in similar scenarios. A sample size of n = 297 undergraduates at Rutgers university volunteered to participate in a study in which they completed six decision problems, spanning two separate decision areas referred to as *arenas* (three decisions in each arena). Decision outcomes in one arena dealt with human lives while the other dealt with financial equity. Based on prospect theory, the researchers hypothesized that human lives would yield higher utility and lead to higher risk-seeking decisions than monetary equity scenarios. Higher risk-averse decisions would be expected in scenarios in which the focus is on equity saved versus lives saved, due to the higher utility associated with lives. The human life arenas presented decision scenarios that involved either lives saved (positive/gain frame) or lives lost (negative/loss frame). These scenarios used the Asian disease problem, a civil defense problem, and a military ambush (Fischhoff, 1983; Kahneman & Tversky, 1982; McKean, 1985).

As described previously, the Asian disease problem asked individuals to choose between two programs designed to combat a disease that is expected to kill 600 people. Choices included, for example, if program A is adopted, there is one-third probability that 600 people will be saved and a two-thirds probability that no people will be saved versus the same scenario. The civil defense problem explains that a committee is discussing contingency plans for a situation in which a train carrying a very toxic chemical derails and the storage tanks begin to leak. In this scenario if nothing is done 36,000 people are expected to die. Individuals are then presented with two possible actions considered by the committee that could be either framed as a gain (i.e., 12,000 lives will be saved, and 24,000 lives will not be saved), or framed as a loss (i.e., there is a 33% chance that no lives are lost, and a 66% chance that all 36,000 lives are lost). For the military ambush problem a general faces a dilemma wherein his intelligence officers explain that 600 of his soldiers will die in an ambush unless he leads them to safety. Safety can be achieved via one of two routes, framed as a gain (i.e., if he takes the first route, 200 soldiers will be saved) and losses (i.e., if the second route is taken there is a 33% chance that no lives will be lost and a 66% chance all lives will be lost).

The monetary problem arena presented decisions involving money gained or lost, including a stock investment problem, an industrial supplier problem, and a researcher-developed home-selling problem (Hogarth, 1987; Roszkowski & Snelbecker, 1990). The stock investment problem asked participants to imagine that they invested $6,000 in the stock market and a downturn in the economy is occurring. They have two investment strategy options to preserve their capital. Options were presented as gains, focusing on capital saved or capital lost. For example, Option A: $2,000 of their investment will be saved or Option B: A one-third probability that the entire $6,000 will be saved, and a two-thirds probability that none of the principal will be saved. The same verbiage was used for losses except the word "saved" was changed to "lost." The industrial supplier problem asks participants to make a choice between two different suppliers for supplies that need to be restocked immediately in a warehouse that does not contain enough spare room. Decision makers must choose between spending more money per supply to receive the appropriate amount of supplies for their warehouse (risk-averse) or spending less money as originally intended and potentially not having a place for the supplies (risk-seeking). For gain scenarios the supplier's offer is phrased as gaining an important cost advantage over major competitors whereas for the loss frame it is phrased as avoid losing an important cost advantage to a major competitor. The home-selling problem explains a recently purchased house is now appraised for only $12,000 more than the price you paid for a home that was worth $36,000 six months prior. A real estate agent suggests two options in the form of either a gain or loss. Each problem involved a choice between a certain alternative and an uncertain or risky alternative of equal expected value.

The decision labels and position of each choice were randomized. Measures included dichotomous coding of whether the decision maker chose the sure option or risky option. Additionally, several demographic questions were included. A simultaneous multiple regression was used to analyze the data from the three primary independent variables and the two methodological variables: frame (positive vs. negative), biological sex at birth, arena (money vs. human life), position of the certain option (first vs. second), and label of the options (A & B vs. C & D). When utility was higher, due to use of human lives, decision choices were much riskier (*M* = 1.80 risky choices) compared to when utility was lower, due to use of financial equity (*M* = .99 risky choices). Participants always made riskier choices when outcomes involved human lives compared to financial equity, regardless of how the scenario was framed. It was anticipated that the higher expected utility of lives saved would also lead to higher risk-averse behaviors in gain-framed scenarios involving human life compared to those involving financial equity, however, this was not observed. A potential reason for this may have been the difference in realism between both scenarios. That is, the money scenario may have held higher utility as it felt more realistic to participants given their age. College students may have had more experience with monetary issues compared to the human life losses yielding a higher utility value. Previous studies have found that experiences can yield differences in utility values (Garling, 1989; Wickens et al., 2017). The findings with respect to loss-framed scenarios were consistent with the expectation for the current study. Despite the findings in gain-framed scenarios, it was expected that in the current study, scenarios that had humans as payload would lead to higher risk-averse decisions compared to payload consisting of cargo. Furthermore, it was not expected that the findings of the Fagley and Miller

(1997) study would be similar to the current study. The current study varied the payload on-board and attempted to keep the other scenario facets identical.

Ronnlund et al. (2005) utilized framing and manipulated utility using three scenarios with varying outcomes at stake, specifically human lives, invaluable paintings, and personal equity. A sample of $n = 384$ individuals participated in the study, each participant was presented with two alternatives, including a description of the potential outcomes, but void of the choice description. The scenario in which the outcome involved human lives utilized Kahneman and Tverksy's (1979) Asian disease problem described previously in this section (Druckman, 2001; Jou et al., 1996; Roszkowski & Snelbecker, 1990). The museum painting problem was used wherein a museum ravaged by fire holds 600 of the world's most famous paintings, and a decision has to be made between choices for the amount of paintings saved or destroyed. The gain-framed scenario focused on paintings saved (Option A: 200 paintings will be saved or Option B: A one-third probability that 600 paintings will be saved, and two-thirds probability that no paintings will be saved). Loss frames focused on destroyed paintings (Option A, 400 paintings will be destroyed or Option B, a one-third probability that none of the paintings will be destroyed, and two-thirds probability that 600 paintings will be destroyed). A personal money scenario was also used, wherein the decision maker is told that a company they just invested 60,000 crowns (i.e., a unit of currency used in Sweden) in filed for bankruptcy and participants must choose between alternative ways to respond leading to money saved or lost. Positive framing focused on money saved (Option A: 20,000 crowns will be saved or Option B, a one-third probability that 60,000 crowns will be saved, and two-thirds probability that no money will be saved). Loss-framed scenarios focused on money that would be lost (Option A: 40,000 crowns will be lost or Option B: one-third probability that no money will be lost, and two-thirds probability that 60,000 crowns will not be lost).

Participants were randomly assigned to either gain or loss framing in each one of the three scenarios. Results indicated that when utility was high, and scenarios focused on loss of human lives, individuals were more risk-seeking compared to lower utility scenarios that involved paintings and personal equity. Personal equity may have been expected to hold higher utility compared to paintings, however, this was not observed in the outcomes as a higher percentage of individuals were more risk-seeking when it came to paintings compared to personal equity. The higher utility found for the paintings may have been due to their rarity as they were described to participants as “the world’s most famous paintings.” Participants likely assigned the paintings higher utility as they could not be as easily replaced whereas, more money can be made.

When examining the results with respect to framing, more participants chose the risky option (63% of participants) in the loss-framed scenarios than the risk-averse option for the human lives. This was also the case in the painting scenarios (53% of participants) but not the monetary scenarios (48% of participants). In gain-framed scenarios, more individuals chose the certain or risk-averse option for scenarios involving human lives (67% of participants), paintings (67% of participants), and money (81% of participants). When examining the interaction between framing and utility, mixed results were found. Consistent with prospect theory, in loss-framed scenarios higher framing effects were found when lives were at stake than paintings or money. However, personal money was not found to hold higher utility than paintings in the loss-framed scenario. One reason may have been that they were described as 600 of the world's most famous paintings leading to higher utility. Additionally, studies have found that other's property can sometimes hold higher utility than that of an individual's own property because of the social aspects (Diederich et al., 2020).

In the context of the current study, it was expected that loss-framed information would yield risk-seeking behavior and gain-framed information would yield risk-averse behavior. In terms of utility, human lives were expected to yield higher utility than cargo. With respect to the interaction between framing and utility, loss framed scenarios with passengers as payload would have a higher number of risk-seeking decisions compared to loss framed scenarios with cargo as payload. Gain-framed scenarios with passengers as payload would have a higher number of risk-averse decisions compared to gain-framed scenarios with cargo as payload.

Aviation Studies Using Prospect Theory

A limited number of studies have examined decision-making using aspects of prospect theory in the aviation domain. These studies focused primarily on how pilots naturally frame information and what factors impact decision-making, however, two studies are particularly relevant to the current study. The findings of these two studies, with respect to framing, tend to align with prospect theory. Pilots tend to partake in risk-seeking behavior for loss-framed scenarios and risk-averse behaviors in gain-framed scenarios (O'Hare & Smitheram, 1995; Walmsey & Gilbey, 2020). Studies in the aviation domain have not, however, focused on utility. The following paragraphs present aviation studies related to prospect theory, ending with the two that are the most relevant to the current study.

Goh and Wiegmann (2001) examined 32 student pilots' decisions to continue or divert from VFR-into-IMC in a simulation flight void of framing to examine pilots natural frame by having pilots select which framed factors were influential to their decision-making. Participants flew two routes using the X-Plane flight simulation program. The first flight was a 15-minute practice flight allowing participants to get comfortable with the program and controls. The second flight was the experimental task, which asked participants to imagine they were conducting a solo cross-country flight of approximately 85 nautical miles as part of their private pilot's license training. Participants were provided with a map and flight plan, detailing routes, landmarks, and alternate airports along the routes for both the practice flight and experimental flight. Participants were provided unlimited time to study the map and flight plan for each route. The experimental flight took approximately 1 hour to complete.

At take-off there were VFR conditions, at around the 45-minute mark, weather conditions began to deteriorate below VFR minimums. Participants were given 5 minutes to make a decision whether to continue or divert, after which the simulation was ended. Demographic information such as age, biological sex at birth, and total, and flight hours were collected. Additionally, before and after the simulation, participants were asked to rate their (a) judgement compared to other pilots, (b) propensity to take risks, and (c) frequency of risk taking, each on a 7-point scale from 1 (much worse, very unwilling very infrequently) to 7 (much better, very willing, and very frequently), respectively. Participants were also presented with 12 factors and asked to rank the importance of these factors in their decision to continue or divert during a flight. Factors were grouped into those pertaining to self or others and factors were presented as gains and losses. The 12 factors were based on those included by O'Hare and Smitheram (1995) and grouped into four categories: (a) tangible gains related to self (the convenience of getting in your car and going home) and tangible losses for self (the possibility of damaging your aircraft), (b) tangible gains for others (getting back so the next person hiring the aircraft is able to take the aircraft on time) and losses for others (the loss of revenue to the club if the aircraft is taken off line for repair), (c) self-approval and disapproval (gain-the opportunity of exercising skill and judgment in difficult conditions and losses-the possibility that you might not be able to handle the conditions), and (d) social approval and disapproval (gain-for other pilots to think positively of your flying skills, or loss-your passengers would be disappointed in your abilities as a pilot if you diverted).

With respect to the findings, more than 68% of pilots made the risk-seeking decision to continue their flight into deteriorating weather. A chi-square test of independence examined whether there was a significant difference in the decision to continue or divert assuming equal likelihood of each decision. A significant difference was found, $\chi 2(1, N = 32) = 4.5$, $p < .05$, suggesting that pilots continued significantly more than they diverted. When examining the results associated with the factors that influenced their decision-making, the factors rated highest by the pilots were those representing in a loss frame. The highest rated factor was to not kill anyone (continue: $M = 6.82$, $SD = .50$; divert: $M = 7.00$, $SD = 0$) followed by the possibility that they may not be able to handle the conditions (continue: $M = 6.23$, $SD = .92$; divert: $M = 6.60$, $SD = 0.52$). Therefore, those who both chose to continue and divert rated loss-framed factors (i.e., loss of life and damaged property) as more important. Pilots who diverted (risk-averse decision) also commonly cited loss-framed factors, potentially due to what has been referred to as the “stickiness of loss frames”, as the effects of loss frames tend to linger longer than gain frames (Ledgerwood & Boydstun, 2014). Therefore, presenting participants with reasons in both gain and loss frames, could lead to anchoring. Participants could be more likely to choose loss-framed scenarios rather than their natural response. In the context of the current study, participants may be more likely to make risk-seeking decisions in scenarios void of framing. The current study only provided participants with framed decision options for framed scenarios. Further, the current study utilized the 12 factors to create framed decision options.

Fischer (2008) conducted two content analyses examining factors influencing decisions and risk response of 61 pilots from U.S. carriers, including 30 major air carriers (an airline that generates more than $1 billion in revenue annually) and 31 national air carriers (scheduled airlines with annual operating revenues between $100 million and $1 billion). Each participant received two realistic decision scenarios, a departure and arrival. Each scenario involved safety and economy goal decision dilemmas under ambiguous and uncertain conditions. The approach scenario took place on Christmas Eve, wherein bad weather is delaying approaches, and a curfew is looming at the destination airport. The scenario highlighted getting passengers to their destination on an important holiday (gain), possibly running out of fuel (loss), accommodating passengers on later flights (gain), and loss of business due to passenger dissatisfaction (loss). The departure scenario stated that as their aircraft, which has been delayed by 4 hours due to poor weather at the destination, moves up the takeoff queue, departure weather is deteriorating. Landing aircraft provide conflicting reports concerning wind shear conditions. Pilots were told they can decide to continue with takeoff although there was a possibility of wind shear, or they could decide not to take any chances and delay their takeoff. Delaying would mean they would go to the end of a long line of aircraft waiting to depart (loss), thereby delaying their departure even more (loss). The study was conducted in a sequence of unfolding events, each scenario could have up to five events depending on when the pilot decided to delay departure on the take-off scenario or divert to an alternative airport in the arrival scenario. Pilots could ask for more information, and the type of information they were allowed to request was determined using six senior pilots affiliated with training at two major U.S. airlines. Participants from major carriers received the study information on flash cards while those from the national carriers performed the study using a computer that presented the material. All materials and instructions were identical for both groups, only presentation media of the material differed. Participants were asked to verbalize all decision-making aloud, including thoughts they had and the steps they would take in each situation.

In the take-off scenario more than 70% of pilots chose the riskier decision (to depart) although there was a chance of wind shear. However, approach scenarios yielded a similar number of responses for each decision option. As previously stated, the occurrence of both negatively and positively framed information may have diluted the effects of prospect theory on the pilots' decision-making. Although authors reported that their findings were not consistent with prospect theory, some of the findings appear to be. For instance, the majority of pilots who decided to take-off noted that they could encounter wind shear and took precautionary action, both supported continuing (risk-seeking) in an uncertain/loss frame. No pattern emerged for the arrival flight, as there was no difference between the number of pilots who continued or diverted. However, one aspect to note is that the approach scenario took place during a holiday recognized by most Americans wherein delays are common (Wu et al., 2019). This may have played a role in the pilot's decision-making. Given that delays are more common during the holidays, pilots may feel more comfortable delaying flights in a scenario in which passengers anticipate delays, potentially lowering the negative utility associated with this scenario compared to other scenarios. Therefore, when pilots are presented with both gain and loss frames they will be more likely to make a decision consistent with risk-seeking The current study did not present both frames at once, to avoid anchoring. However, as the current study design was repeated measures, participants will have at some point received both frames and this may lead to them being more risk-seeking in the final scenarios of the study.

Walmsley and Gilbey (2020) examined the effects of framing and utility in 10 flight scenarios using 132 pilots. The study presented each scenario as a possible flight route using a simplified map/graphic to help participants visualize the scenario. There were five scenarios framed as a gain and the same five scenarios presented using loss framing, totaling ten scenarios. Four out of the five scenarios used weather as the adverse event, while the final used an air traffic control (ATC) delay. The format of the uncertain events was presented as probabilities such as

30% chance of thunderstorms. This presentation was used to reflect pilot's real-life decision-making information. Four of the scenario choice options focused on money either lost or gained, while the other four scenarios focused on the chances of arriving early (gain) or late (loss). Additionally, scenarios 4 and 5 manipulated utility using different reference points, that is, the amount of time and money to start with. An example of the first scenario presented in a gain frame is provided below.

> Your income for a flight is based on how quickly you can complete the flight. Today you have two routes to choose from to reach your destination. Route A (risky): is the quickest route, with an 85% chance the weather will be suitably fine, resulting in $1,000 income. If the weather is not suitable you will need to turn around and take a long route, resulting in $0 income. Route B (Certain) could be flown for sure (weather is fine), but as it is a little longer, it would only result in a $800 income (Walmsey & Gilbey, 2020, p. 10.)
>
> An example of a loss-framed scenario is:
>
> Imagine that you have hired a Cessna 172 for a few days. Today you need to return the aircraft. If the aircraft is returned late, you will need to pay a late fee. You can choose from two routes; Route A (risky): is the quickest

> route, that would avoid late fees, as the aircraft would be returned on time. However, there is an 85% chance the weather would be poor, requiring a longer route and returning very late with late fees of $1,000. Route B (certain): could be flown for certain (weather is fine), but as it is a little longer, would result in you arriving slightly late, with late fees of $800 (Walmsey & Gilbey, 2020, p. 11.)

The second scenario used a similar format with the same probabilities, except the certain gain ensured the pilot would be 45 minutes early and the uncertain gain posed an 85% chance of being 60 minutes early. The losses for the second scenario stated that the first route would certainly lead to a late arrival of 45 minutes and the uncertain route provided an 85% chance of being 60 minutes late. The non-weather-related scenario, specifically an ATC delay, used the same outcomes as the first scenario. An ATC delay was used to determine if any difference occurred between decision-making in weather and non-weather-related scenarios. The fourth scenario presented as a gain and with a reference point stated:

> Imagine that prior to the flight you have been given $1,000; you can also receive extra money depending on how quickly you can complete the flight. Today you have two routes to choose from to complete your flight; Route A is the quickest route and would provide an extra $1,000. However, there is a

> 50% chance the weather will not be suitable which would require a longer route and therefore no extra money. Route B, could be flown for sure (weather is fine), resulting in an extra $500 for certain (Walmsey & Gilbey, 2020, p. 13.)

The fourth scenario presented as a loss and with a reference point stated:

> Imagine that you are flying a Cessna 172 on a VFR flight; before the flight you have been given $2000. How much of this money you can keep depends on how quickly you complete the flight. Today you have two routes to choose from; Route A is the quickest route, which would mean you can keep all the money. However, there is a 50% chance the weather will be poor, requiring a longer route, arriving late, therefore give back $1,000. Route B could be flown for certain (weather is fine), but as it is a little longer, would result in you arriving slightly late, therefore give back $500 (Walmsey & Gilbey, 2020, p. 13.)

The fifth scenario was identical to the first except it used times, a certain gain provided a sure 15 minutes early and an uncertain gain provided a 50% chance of arriving 30 minutes early. Whereas a certain loss provided a sure 15-minute late arrival, while the uncertain route provided a 50% chance of being 30 minutes late. After the scenarios ended, to obtain their natural frame, participants were asked to select how they consider a decision to divert during adverse weather. Next, participants were presented with a scenario asking them to imagine they are half-way (2 hours in) through a VFR cross country flight and have to divert to an unfamiliar airport due to low visibility and low clouds. They were then asked to choose two out of four provided statements that best described their feelings in that scenario. Two of the statements were gain framed (i.e., diverting will ensure the safety of aircraft and its occupants, it is always better to be cautious and divert early when the weather is poor), while the remaining were loss framed (i.e., diverting involves a lot of hassles and inconveniences, the costs involved in the flight would have been wasted). The order of the statements was randomized.

When examining the findings of the study, mixed results were found. Pilot decision-making under uncertainty was not always consistent with prospect theory. In the first scenario, wherein money was either gained or lost, framing effects consistent with prospect theory were examined. McNemar's test was run to determine whether a significant difference was present between framing conditions (gain framing or loss framing) and whether the decision outcome was risk-seeking. There was a statistically significant difference ($p < .001$). More participants were risk-seeking in loss-framed routes compared to gain-framed routes. Specifically, when pilots were faced with route options framed as gains, 81.1% of pilots selected the certain or risk-averse route. When route options were framed as losses, 57.6% of pilots selected the uncertain or risk-seeking route. The second scenario utilized time-based outcomes, and only yielded framing effects for gains. When options were framed as gains, 87.1% of participants chose the certain route. Interestingly, when faced with losses, pilots were also risk-averse, specifically, 54.5% of pilots chose the certain time route ensuring that time would be lost. When examining the ATC related third scenario, in gain-framed routes 72.0% of the pilots selected the certain or risk-averse decision. When presented with loss-framed scenarios, 61.4% of pilots chose the uncertain, risk-seeking route. McNemar's test determined there was a statistically significant difference in the risk-seeking decision outcome between frame groups (gain vs. loss framed), $p < .001$. A greater percentage of pilots chose the uncertain risk-seeking option in the loss-framed route compared to the gain-framed route. In the fourth scenario wherein money was in question and a reference point was included, 85.6% of the pilots faced with gain-framed scenarios selected the certain or risk-averse route, despite the two options having the same utility. However, when examining the scenario in a loss frame, framing effects did not hold true. Participants in the loss frame chose the risk-averse route 62.9% of the time. McNemar's test determined that there was a statistically significant difference in the frequency of pilots who chose the risky decision based on the framing method, ($p < .001$). More pilots in the loss-framed routes chose the risk-seeking option than in gain-framed routes.

In the final scenario, examining a time-reference point in weather-related decision-making, similar results to the fourth scenario were found. When the scenario was framed in terms of gain, 81.8% pilots chose the certain or risk-averse outcome. However, inconsistent with prospect theory, when the scenario was framed in terms of losses, 58.3% of pilots chose the risk-averse option. McNemar's test determined there was a statistically significant difference in the risk-seeking decision outcome between frame group (gain vs. loss framed, ($p < .001$). A higher frequency of pilots selected the riskier route in the loss-framed time route ($n = 55$) compared to gain-framed time routes ($n = 24$). When examining natural frames, differences also emerged. An independent-samples t-test comparing participants' natural frames and risky decisions found a significant difference in the number of risk-seeking selections between the two groups, $t(122) = 1.98$, $p = .05$. Participants who selected losses only or gain-framed and loss framed statement (in the natural framing question) were categorized as having a natural loss frame, while those who only chose gains were considered to have a natural gain frame. Those who were categorized as loss framed, chose the risk-seeking decision option more often (43.5%) than those who were naturally gain-framed (26.8%).

In summary, mixed results were found, as framing effects held true for gain-framed scenarios but were not always consistent in loss-framed scenarios. These findings may be due to differences in utility and represent the interaction between framing and utility. In gain-framed scenarios regardless of whether it was time or money that was certain, pilots tended to be risk-averse and selected the route with a definite outcome. However, in loss-framed scenarios in which time could be lost, pilots also select the risk-averse/certain route. The authors suggested that pilots may treat time differently as it is important in calculating fuel, therefore indicating that regardless of frame when time is in the equation, they will be more cautious. However, McNemar's tests do not support this as there was a significant difference in the frequency of pilots who chose the risky decision based on whether they received the gain or loss framed scenario. Additionally, if time was more important and held higher utility, it would be expected that pilots would have made more risk-seeking decisions in the loss frame. Potentially, time is not as important to pilots as other factors such as human lives or social aspects. Additionally, it may be that the difference in utility between 15 and 30 minutes lost or 45 and 60 minutes lost may not be large enough to produce any differences in decision. That is, the utility value is very low and therefore the pilot would not be willing to partake in risky behavior to avoid a loss.

When examining the scenarios with money, prospect theory held true in the first scenario, however, it did not hold true in the scenario that included a reference point. The difference may be that in the first scenario, the participant is starting with no money, so they are willing to take a risk to avoid losing personal money. The sure loss of $800 would hold a high utility, so they will take the risk to avoid losing any money. Whereas the second scenario, the participant is starting off with $2,000 and the sure loss is lower, with a loss of $500. As Kahneman and Tversky (1979) have explained, the farther one gets from the origin, the slope of the value function decreases indicating diminishing perceived utility for both gains and losses. Finally, the non-weather ATC scenario was consistent with prospect theory as participants were risk-seeking for loss framed scenarios and risk-averse for gain-framed scenarios. As the authors had stated, pilots used in the sample were young student pilots or staff at a flight school. All of these individuals would have experience with ATC and likely could relate strongly to the scenario with ATC, yielding higher utility. As discussed previously, studies have found that experiences can yield differences in utility values (Garling, 1989; Wickens et al., 2017). With respect to the current study, when utility is low, framing effects may be higher for gain-framed compared to loss-framed scenarios. If the weight of the loss is low for both decision options (i.e., Option A: the package will be ten minutes late vs, Option B: A 60% chance the package will not be late but a 40% chance the package is 45 minutes late) pilots may act in a risk-averse manner and take the safe route as they do not feel the loss is worth the risk. However, if utility is high such as loss of human lives in the loss frame, prospect theory would hold true, and pilots would be more likely to act in a risk-seeking manner. Additionally, as student pilots and helicopter pilots may have had different experiences, participants may respond differently to the differing payloads.

The earliest study applying prospect theory in the field of aviation was conducted by O'Hare and Smitheram (1995). O'Hare and Smitheram examined the application of prospect theory to pilots' decisions about whether to continue into deteriorating weather, specifically visual flight rules into instrument meteorological conditions (VFR-into-IMC). The scenario was set during a cross-country flight in a manned general aviation aircraft, returning after a weekend trip (1995). The study consisted of a volunteer sample of $n = 24$ male pilots from New Zealand with up to 2,500 hours as pilot-in-command. In this study, participants were provided with the scenarios framed in terms of losses (certain vs. risky) or gains (certain vs. risky) to see if this altered their decision to divert or continue. The study was conducted on a laptop computer that presented pilots with weather information, aircraft performance information, topographical maps, and aircraft performance charts.

Participants then completed a simulated cross-country scenario in which they would be asked to decide whether to continue or divert given the information they had available at a certain point in the flight. Participants were given practice to familiarize themselves with the simulation. The scenario presented to the participants explained that they were flying a short cross-country flight in a rented aircraft across the North Island of New Zealand. At approximately three fourths of the way through the flight they were told that conditions at their destination were marginal visual flight rules (VFR). Participants had to make the decision whether to continue into deteriorating weather or divert. Participants who were presented with losses were reminded of the time and money invested thus far in the flight, for example:

> Diverting from the planned flight will certainly involve lots of hassles and inconveniences, and the costs involved in the flight will have been wasted, whereas continuing the flight, the chances of being involved in an accident involving injury or damage to the aircraft are most unlikely (O'Hare & Smitheram, 1995, p. 8)

Those presented with gain-framed statements were encouraged to ignore past losses and shift their point of reference to benefits or gains of the flight, for example:

> Diverting from the planned flight will certainly ensure that the aircraft and its occupants are undamaged, and the pilot's record remains untarnished, whereas if the flight is continued, the chances of getting safely through to the original destination are uncertain (O'Hare & Smitheram, 1995, p. 8)

Decisions and the response latency were collected for their decision, specifically whether participants continued or diverted the flight and the amount of time it took participants to make their decision. Participants were also asked to indicate what gains and losses they consider when making the decision to continue or divert from Janis and Mann's (1977) balance-procedure sheet. Eight factors were presented to the participants. First, tangible gains related to self (the convenience of getting in your car and going home) and tangible losses related to self (the possibility of damaging your aircraft). Second, tangible gains for others (getting back so that the next person hiring the aircraft was able to take the aircraft on time) and losses for others (the loss of revenue to the club if the aircraft was taken offline for repair). Third, self-approval and disapproval (gain-the opportunity of exercising skill and judgment in difficult conditions and losses-the possibility that you might not be able to handle the conditions), and finally, social approval (that your passengers would be impressed by your skills as a pilot) and social disapproval (that your passengers would be disappointed in your abilities as a pilot).

Participants rated each factor on a 7-point scale from 1 (very important) to 7 (not important) on how much the item contributed to their decision to continue the flight.

Results of the study were consistent with framing effects. Sixty seven percent of participants in the negative frame decided to continue (a risk-seeking choice) compared to 25% of participants continuing in the positive frame. A chi-square test of independence revealed a significant difference between the number of people who chose each decision outcome and the framing condition, χ^2 (1, N = 24) = 4.2, $p < .05$. Participants presented with loss frames were significantly more likely to continue (risk-seeking) than those in the gain frames. Those who received gain-framed scenarios were more likely to choose the risk-averse decision and divert. These findings suggest that it may be possible to influence UAM pilot weather-related decision-making by using positive or negative framing to manipulate how decision options surrounding weather-related decision-making.

A *t*-test comparing frames and decision latency found no significant difference in the time it took participants to respond between the two frames, $t(22) = 0.64$, $p > .05$. Losses and gains did not yield differing response times. Additionally, when examining the importance ratings for factors influencing participants decision to divert, the two highest rated statements were loss framed.

The statements participants felt were the most important to their decision were loss framed, specifically "the possibility of damaging the aircraft" (rating of 2.7) and "the possibility that you might not be able to handle the conditions" (rating of 2.9). The findings with respect to importance ratings point to how losses are more concerning or felt more impactful by individuals compared to gains. Therefore, it was hypothesized that UAM pilots would be more likely to divert (risk-averse) when a scenario is framed in terms of gains compared to losses. Additionally, there was a potential for framing (void of utility) to not yield differences in decision time.

Summary and Study Implications

In summary, the literature reviewed in this chapter suggests that both utility and framing impact decision makers responses. Framing information using Kahneman and Tversky's (1979) gain-framing structure commonly led to risk-aversion, whereas framing information using loss frames led to risk-seeking (Abdellaoui et al., 2013; de Souza et al., 2020; Druckman, 2001; Guo et al., 2017; O'Hare & Smitheram, 1995; Ronnlund et al., 2005; Roszkowski & Snelbecker, 1990). Although only two aviation studies examined framing in the traditional manner, and both studies presented participants with either gain- or loss-framed scenario information and asked them to make a decision (O'Hare & Smitheram, 1995; Walmsley & Gilbey, 2020). Of these, O'Hare and Smitheram (1995) found framing effects consistent with prospect theory, while Walmsey and Gilbey (2020) found mixed results as framing was found consistently for gain-framed scenarios but not all loss-framed scenarios. In non-aviation research, there were also instances in which framing effects were not found for all gains (Fagley & Miller, 1997). Some of these differences may be explained by anchoring and differences in utility. For example, in Fagley and Miller (1997), riskier decisions were made for scenarios involving human lives regardless of frame. This may be due to participants having received both loss- and gain-framed scenarios leading to anchoring, as literature has highlighted that losses stay with individuals longer (Ledgerwood & Boydstun, 2014). Additionally, lives may have held such high utility that participants were risk-taking, regardless of frame, in attempt to avoid a loss (e.g., Zhou et al., 2021).

When examining the results of utility manipulation on decision-making, many studies were consistent with prospect theory (de Souza et al., 2020; Diederich et al., 2020; Fagley & Miller, 1997; Jou et al., 1996; Ronnlund et al., 2005; Roszkowski & Snelbecker, 1990). That is, as utility increased so too did risk-seeking. However, there was an instance in which risk-seeking was lower when it would have been expected to be higher due to utility. For example, Zhou et al.

(2021) found that individuals were more risk-seeking in loss scenarios wherein the decision outcome affected fish lives compared to scenarios in which the decision outcome affected human lives. Similar results were found in one study in the aviation domain (Walmsey & Gilbey, 2020). Specifically, individuals were more risk-seeking in loss scenarios where they could lose money compared to scenarios where they could lose time. When reference points were added to manipulate utility, no differences were found. Overall, these findings may be due to the individuals being unwilling to partake in any risk as they do not want to potentially maximize their loss. Additionally, with respect to Walmsey and Gilbey (2020), the results may be due to the low benefits associated with partaking in risk-seeking for the losses compared to the risk-averse options. In the loss-framed scenario associated with time, their decision options were between a potential increased loss in time from 15 and 30 minutes or a sure loss of 45 and 60 minutes. The potential to not lose between an additional 30 minutes may not be large enough to produce any differences in decision. The utility value of 30 minutes may be very low and therefore the pilot would not be willing to partake in risky behavior to avoid a loss.

Several cited studies found an interaction between framing and utility (Jou et al., 1996; Roszkowski & Snelbecker, 1990; Souza et al., 2020; Zhou et al., 2021). Cited research indicated that, in most cases, framing effects are stronger for lower utility in gain-framed scenarios and stronger for higher utility in the loss-framed scenarios (Jou et al., 1996; Roszkowski & Snelbecker, 1990; Souza et al., 2020; Zhou et al., 2020). There were some exceptions to this such as in one of the Zhou et al., (2020) studies, in which human lives did not yield the lowest risk-aversion in the gain-framed scenarios. The interaction between framing and utility was observed in one aviation study (Walmsey & Gilbey, 2020). The results were consistent with framing effects being stronger in gains for lower utility scenarios, however, no high utility scenarios were included.

The studies cited provide significant support for the pre-stated hypotheses of the current study, that payload consisting of humans would yield higher utility values than cargo. When examining the effects of utility on decision times, the literature supported that lower decision times would be found in scenarios that held higher utility. Specifically, decision times would be lower for scenarios with passengers than cargo. Additionally, with respect to framing, scenario information framed in terms of losses would yield risk-seeking behaviors while gain-framed scenarios would yield risk-aversion. One study supported that framing would have no effect on decision time. When examining the interaction between framing and utility, the literature suggests that framing effects would be stronger for cargo than passengers in gain-framed scenarios. The reverse would be found in the loss-framed scenarios, as the literature supports framing effects would be stronger for passengers over cargo. When examining the interaction between framing and utility on decision time, the literature suggests, gain-framed scenarios with passengers as payload would have a shorter decision time compared to gain-framed scenarios with cargo as payload. Furthermore, loss-framed scenarios with passengers as payload would have a shorter time compared to loss-framed scenarios with cargo as payload.

No studies to date have examined the influence of prospect theory on the riskiness of weather-related decision-making in the UAM context, nor has a study examined the impact of manipulating utility based on whether an aircraft has passengers onboard. UAM is quite a different context from the traditional manned-aviation contexts utilized in the research cited. An interesting aspect of the UAM piloting task that differs from the traditional manned-piloting task is that the pilot will be remotely operating the aircraft. At times UAM pilots will have passengers onboard and at other times they will only have cargo onboard. It is currently unknown how differing payloads will impact UAM decision-making in a risky situation.

Further, although studies with weather-related decision-making can inform UAM, the challenges and consequences associated with weather phenomena that

UAM pilots will experience will be vastly different. UAM pilots will be flying at much lower altitudes that significantly shorten the time a pilot has to recover before potentially encountering an obstacle like a building. The type of aircraft UAM pilots will be flying may be smaller and lighter than a typical general aviation (GA) plane, which makes it less robust against inclement weather, and any adverse weather, such as, wind shear which can significantly affect the aircraft.

The current study was an extension of O'Hare and Smitheram's (1995) study, which examined the application of prospect theory to pilot weather-related decisions in a manned aircraft context. Pilots decided whether to continue into deteriorating weather or to return to the departure site. However, the current study extended this work in two key ways. First, the current study extended this work by manipulating utility, or the subjective value of the potential loss/gain associated with the decision, by manipulating whether or not humans are onboard the remotely-piloted aircraft. Second, the current study extended this work by examining the impact of framing on a weather-related decision-making in a new performance context, that of piloting a remotely-controlled UAM aircraft. Specifically, pilots decided to continue or divert a flight that (a) they are remotely operating, (b) with potential outcome consequences related to safety of either other individuals or cargo, (c) took place at a lower altitudes, and (d) in weather that may be considered mild for traditional manned aircraft, but more severe for a UAM aircraft, and (e) with flight times and decision times that are shorter. The current study's results could provide insight into the potential effects of framing and utility on the riskiness of weather-related decision-making, and could provide useful information for future original equipment manufacturers (OEMs) and UAM training design.

Chapter 3

Methodology

Population and Sample

Population

The target population for the current study was helicopter pilots, GA pilots, and UAS pilots. These pilots were selected as future UAM operations are expected to be somewhat like those experienced by helicopter pilots, GA pilots, and UAS pilots, but the extent of each is not known and is expected to unfold as UAM evolves (Archdeacon & Iwai, 2020; Goodrich & Theodore, 2021; NASA, 2018). Further, in the last few months the FAA confirmed that they plan to use their special class process in 14 CFR 21.17(b) to type certificate powered-lift aircraft that uses the performance-based airworthiness standards found in Part 23 of the FAA regulations (Reed, 2022). As a result, there will need to be a mix of training from helicopter operations and airplane operations due to the use of both helicopter and airplane modes in eVTOLs. Although the FAA did not touch on remote operation, it is widely understood that the future of UAM will ultimately be remote operation (Cenk Ertürk et al., 2020; Pons-Prats et al., 2022). Therefore, demographics for helicopter pilots, GA pilots, and UAS pilots were pulled from publicly available statistics and compared to the statistics for helicopter pilots, GA pilots, and UAS pilots in the current study's sample (see Table 3.1). The accessible population included Florida Tech students who had flight or UAS experience, members of Helicopter Association International (HAI) who had flight experience, members of the National Association of Flight Instructors (NAFI) with flight experience, and any individuals with flight experience who had access to the ATLAS Lab LinkedIn page directly or indirectly. Students with flight experience and UAS experience were representative of future UAM pilots due to their knowledge of airspace and their experience flying smaller aircraft at lower altitudes (13,000 – 15,000 AGL for aircraft and up to 400 AGL for drones). Additionally, helicopter pilots from HAI were considered representative of future operators due to the expected similarities in the aircraft handling qualities and operating at lower urban altitudes, similar to those envisioned for UAM operations (Archdeacon et al., 2020). Members of NAFI with flight experience were considered representative due to their experience flying smaller aircraft and at lower altitudes much like the flight students. Additionally, helicopter operations used to transport individuals have been considered an early form of UAM (Kohlman & Patterson, 2018; Mofolasayo, 2020). Finally, UAS pilots who accessed the survey were considered representative due to their experience remotely-operating smaller aircraft at lower altitudes.

Table 3.1

Target Population Demographics Compared to Sample Demographics per Operator Type

Operator Type	Age *M*	Total *N*	Male *n*	Male %	Female *n*	Female %
Commercial Helicopter						
United States	45.9	9,510	8,872	93.3%	637	6.7%
Sample	41.8	6	6	100%	--	--
Commercial GA Pilots[a]						
United States	45.9	77,890	73,761	94.7%	4,128	5.3%
Sample[b]	29.8	49	42	85.7%	6	12.2%
Remote Pilot Certification						
United States	41.9	160,302	149,484	93.3%	10,818	6.7%
Sample	32.8	10	10	100%	--	--

Note. Statistics pulled from United Stated Department of Transportation U.S. Civil Airmen Statics. (2019) excluding student pilots and remote pilot certification was pulled from the U.S. Civil airmem fact sheet.

[a]Commercial GA pilots does not include helicopter or gliders

[b]One participant in the sample did not identify their gender

Sample

The sampling strategy used to obtain students from the accessible population was convenience sampling and snowball sampling. To obtain student participants, fliers were posted in Florida Tech's College of Aeronautics (COA), Florida Tech's flight line, online to the university's list service, and students were also recruited through Florida Tech's COA classes wherein extra credit was made available for their participation in the study. Any individual who was 18 years of age or older and had flight experience was allowed to participate. The same flier was distributed to members of HAI and NAFI, and via LinkedIn.

A total of 98 participants accessed the survey study. However, of those 46 were removed for various reasons. Data that were removed fell into the following categories: (a) identified as spam or fraudulent submissions by online bots, (b) did not partake in any of the scenarios (i.e., the main task), (c) did not complete all scenarios, (d) did not meet the requirements for inclusion (i.e., 18 years of age and flight experience), or (e) were identified as outliers. The complete breakdown including the number of participants per reason is included in detail in the missing data section of Chapter 4 of the current work. The final sample consisted of a total of $N = 52$ participants. The following demographic data are summarized descriptively in the tables below: biological sex at birth, race, ethnicity, type of flight experience, level of flight experience, video game experience, and video game frequency (see Appendix D for demographics). The descriptive statistics of the sample's demographic information are made available to readers to allow them to draw their own conclusions related to generalizability.

Table 3.2
Summary of Participants' Race/Ethnicity by Sex

		Race[b]						Ethnicity[c]			
		White		Black		Asian		H/L		Not H/L	
Group[a]	***N***	***N***	**%**	***N***	**%**	***N***	**%**	***N***	**%**	***N***	**%**
Female	6	4	67%	0	0%	2	33%	0	0%	6	100%
Male	45	25	56%	4	9%	10	22%	4	9%	41	91%
Overall	51	29	57%	4	8%	12	24%	4	8%	47	92%

Note. $N = 51$.
[a] One participant did not respond to this item. [b] 7 participants identified as "other" [c] H/L = Hispanic/Latino.

Table 3.3
Summary of Participants' Age by Sex

	Age[a]			
Group[a]	***N***	***M***	***SD***	**Range**
Female	5	23.40	2.30	21–26
Male	38	29.44	15.11	18–75
Overall	43	29.57	15.19	18–75

Note. $N = 43$.
[a]Eight participants did not share their age and one participant selected, "I prefer not to say".

Table 3.4
Summary of Participants' Flight Experience by Sex

		Type of Flight Experience						UAM Class Experience			
		Fixed Wing		Rotary Wing		UAS		Yes		No	
Group[a]	***N***	***N***	**%**	***N***	**%**	***N***	**%**	***N***	**%**	***N***	**%**
Female	6	6	100%	0	0%	0	0%	0	0%	6	100%
Male	45	42	93%	6	13%	10	22%	1	2%	44	98%
Overall	51	48	94%	6	12%	10	20%	1	2%	50	98%

Note. $N = 51$.
[a]One participant did not respond to the question.

Table 3.5

Summary of Participants' Fixed Wing Experiences (in Years) by Sex

		< 1		$1 \leq x < 3$		$3 \leq x < 5$		≥ 5	
Group[a]	***N***	***N***	**%**	***N***	**%**	***N***	**%**	***N***	**%**
Female	6	1	17%	2	33%	3	50%	0	0%
Male	45	9	20%	19	42%	5	11%	9	20%
Overall	51	10	20%	21	41%	8	16%	9	18%

Note. $N = 51$.
[a]Three participants did not respond to the questions

Table 3.6

Summary of Participants' Video Game Experiences by Sex

		None		< 1		$1 \leq x < 3$		$3 \leq x < 5$		≥ 5	
Group[a]	***N***	***N***	**%**	***N***	**%**	***N***	**%**	***N***	**%**	***N***	**%**
Female	6	1	17%	2	33%	0	0%	0	0%	3	50%
Male	45	3	6%	5	11%	6	13%	2	4%	29	64%
Overall	51	4	8%	7	14%	0	0%	0	0%	32	63%

Note. $N = 51$.

Table 3.7

Summary of Participants' Video Game Frequencies by Sex

		Never		Daily		Weekly		Monthly		Yearly	
Group [a]	***N***	***N***	**%**	***N***	**%**	***N***	**%**	***N***	**%**	***N***	**%**
Female	6	1	17%	0	0%	0	0%	3	50%	2	33%
Male	45	6	13%	9	20%	17	38%	8	18%	4	9%
Overall	51	7	8%	10	20%	17	33%	11	22%	6	11%

Note. $N = 51$. 1 particiapnt reported "multiple times per day and was not included in the table above.

Power Analysis

Prior to conducting the study a priori power analyses were conducted. The first power analysis was conducted for a chi-square analysis. A minimum sample size was calculated using an effect size of .5, a power of .8, and an alpha level of .05, using G*Power 3.1 (Faul et al., 2007). The power analysis resulted in a minimum sample size of 52 participants. A second power analysis was conducted for a repeated measures within factors MANOVA with assumed values. A minimum sample size was calculated using an effect size of .25, a power of .80, and an alpha level of .05. The power analysis resulted in a minimum sample size of 40 participants. Therefore, the final minimum sample size required in the study was $N = 52$ and this number of participants was obtained for the current study, with the observed power calculations from the final analysis presented in Table 3.8.

Table 3.8

Power Analysis and Calculated Powers for α = .05

Factors	ES	Power	*p*
Frame	.378	.993	<.001
Payload	.101	.527	.070
Frame*Payload	.050	.192	.642

Note. $N = 52$.

Experimental Design and Independent Variables

Research Methodology/Design

The current study used an experimental design, specifically, a within groups 2 (human vs. cargo) by 3 (no frame vs. positive frame vs. negative frame) repeated measures design examining impacts on decision outcome (both a categorical and continuous measure of decision outcome), and decision time. A repeated measures design was appropriate as there was only one group, and each participant was administered all treatments. A repeated measures design can help to control for individual differences among subjects, such as experience or skill levels, as each participant acts as his or her own control. The study manipulated two independent variables, payload type and frame. Payload type had two levels, either passengers or cargo onboard the aircraft. Payload served as a manipulation of utility. Frame had three levels: no frame, gain frame, and loss frame (see Figure 3.1.)

Figure 3.1
Research Design

		Frame Condition		
		No Frame	Gain Frame	Loss Frame
Payload Type	Cargo	Scenario A	Scenario B	Scenario C
	Passenger	Scenario D	Scenario E	Scenario F

Note. Scenarios were counter-balanced to avoid order effects.

Human Subject Research

An IRB application was submitted to the Florida Tech Institutional Review Board as the current study fell under human subject's research. The risks of participation in the current study did not exceed the risks of normal everyday operation on a desktop computer. The data were collected via Qualtrics and only my advisor and I had access to the data. No names or emails were collected with the data to ensure anonymity (See Appendix A).

Description of Dependent Variables

The current study obtained data for two primary dependent variables using three measures. Demographics were collected to provide information relative to the sample's representativeness. Finally, three secondary dependent variables were examined as potential covariates to determine if they could explain differences in the riskiness of weather-related decision-making.

Decision Outcome. Participants' decision outcomes were captured using two measures. First, the decision outcome was measured categorically following each of the six simulated flight scenario recordings. Participants were asked to make a weather-related decision as to whether to continue to the destination site (risk-seeking decision outcome) or return to the departure site (risk-averse decision outcome). This measure was included to provide the most operationally relevant measure of decision outcome. To obtain this measure, once the participant finished viewing the recording of the flight and selected next on the Qualtrics page, the upcoming adverse weather was presented in one of the three frames. The participant was asked to make a decision based on the presented information via a Qualtrics survey. This resulted in a categorical-decision outcome variable for each scenario that was utilized to calculate frequencies (see Appendix E). This method (i.e., categorical decision) is the method that has been used in prior aviation studies using prospect theory. A Cronbach's alpha could not be generated for the measure. The dichotomous decision outcome variable heavily relied on the literature and attention to face and content validity was achieved by having a human factors expert and a general aviation expert review the queries for accuracy.

Second, to obtain a decision outcome in the form of a continuous variable, a 1-item researcher-developed scale that asked participants to select which response characterized the decision they made to either continue or divert in the last scenario completed (See Appendix E). Participants rated their answer on a 5-point rating scale from 1 = Highly agree to divert, 2 = Agree to divert, 3 = Neither agree to divert or continue, 4 = Agree to continue, and 5 = Highly agree to continue. Similar scales have been used to capture a continuous measure of decision outcome (Pauley et al., 2008). Post hoc it registered that the wording was not precise with the categorical decision measure, therefore findings need to be interpreted with caution. Attention to face and content validity was achieved by having a human factors expert review the questions for accuracy. Further, given that the continuous decision outcome variable was assumed to be related to the dichotomous decision outcome variable, construct validity was obtained by examining the correlation between the scores and each yielded high correlations. The Cronbach's alpha was calculated for the continuous decision outcome variable and was moderately high, □□= .658.

Decision Time. Decision time was collected using a timer feature in Qualtrics that was embedded on the webpage that asked participants to make the categorical decision. The timer started when the page with the framed/non-framed decision options loaded and ended when the participant selected the next button after selecting a decision. Decision time was measured in seconds. Cronbach's alpha was calculated and was moderately high, □□= .812.

Demographics and Covariates

The following variables were collected to provide readers with information relative to the sample's representativeness to allow for replication of the current study.

Demographics. All study participants were provided with a survey prior to the task in which they were asked to report their age, race, ethnicity, biological sex at birth, type of flight experience (Flight and UAS), certificate level, gaming experience, and flight simulator experience. Experience questions were asked to capture any differences in experience that could potentially influence decision-making. Students received one additional question asking them whether they had taken the Urban Air Mobility (UAM) course at Florida Tech. This question was included to understand whether students taking the course may be more attune to safety hazards associated with the UAM domain. All demographics were collected using a Qualtrics survey prior to starting the task (See Appendix C).

Workload. Perceived workload was captured as a potential covariate that could explain differences in riskiness of decisions. Workload was measured using the National Aeronautics and Space Administration-Task Load Index (NASA-TLX). The NASA-TLX was administered after each of the six scenarios. The 6-item, 20-point scale measures six dimensions of workload: mental demand, physical demand, temporal demand, performance, effort, and frustration. For example, “How hurried or rushed was the pace of the task?” and “How successful were you in accomplishing what you were asked to do?”. The NASA-TLX has been used for more than 20 years in hundreds of studies (Hart, 2006). The NASA-TLX has been shown to have high reliability, Cronbach’s alpha was calculated, □□= .960. The question was administered to participants via Qualtrics after they answered the continuous decision outcome variable (see Appendix F).

Risk Propensity Scale. The second measure that was examined as a potential covariate was risk propensity. Participants were asked to rate their general risk tendencies using the Risk Propensity Scale (RPS). Meertens and Lion’s (2008)

7-item RPS was used to measure participants' risk tendencies. The RPS scale poses questions such as "I prefer to avoid risks" with a 9-point scale ranging from 1 = totally disagree to 9 = totally agree. However, the final item posing the question "I view myself as a… has different anchors for the 9-point scale from 1 = risk avoider to 9 = risk seeker. For validity the RPS has been shown to have a significant negative correlation with the Need for Structure scale (NFS), this was the expected relationship (Meertens & Lion, 2008). The scale was administered after all the scenarios were completed in the post-task survey (see Appendix G).

Weather-Related Perceived Risk. The third measure that was included as a potential covariate, based on feedback during the proposal stage, to further understand the sample was a weather-related measure of perceived risk. The measure asked participants to rate the level of risk associated with the weather they encountered during the study, including the risk related to marginal winds (i.e., 15-20 knots), moderate precipitation, and marginal visibility due to clouds, on a 3-point scale from Low risk to High risk. These data were included to further describe the sample and the scores of the weather-related perceived risk measure was examined as a covariate (see Appendix H). Internal consistency scores nor Cronbach's alpha could be calculated for the risk propensity scale and the weather-related risk scale as the items in each target risk with respect to different pieces of information. Inter-item correlations would likely be low for the risk propensity items as the statement of safety first does not indicate whether you will take risk with your health. Further, the weather-related risk queries are the same as an individual's feelings relative to wind do not indicate how they feel about rain, these are two different weather types. Finally, due to these items only being collected once, there was no way of obtaining test-retest reliability.

Study Implementation

Experimental Testbed. The study was created using Microsoft Flight simulator and Qualtrics. The Microsoft Flight simulator was used as it had an eVTOL that was fully functional, created by one of the companies in the certification process, and presented information that has been seen in many of the eVTOLs pilot interfaces that are publicly available. The eVTOL was the Volocity Volocopter. Further, Microsoft flight simulator allowed for the manipulation of weather and had realistic graphics due to the utilization of Microsoft's Azure Cloud Artifical Intelligence and both aerial and satellite imagery. Originally, participants were going to perform the scenarios in the simulator, however, a significant limitation was encountered with the platform. Although specific weather could be saved, the location of the weather within the airspace was not constant. That is, participants could start in a cloud in some scenarios and not in others. After consulting subject matter experts, the decision was made to change the study to a vignette-based approach. Therefore, instead of participants flying the scenarios within the simulator, the scenarios were recorded and embedded into a Qualtrics survey to ensure that participants experienced the same weather across scenarios. Ten 1 minute flights were recorded in Microsoft Flight simulator using Open Broadcaster Software (OBS), a free and open-source video recording software. Subject matter experts were presented with the flights and consulted to ensure the weather matched the information presented to participants. Six out of the 10 flights were deemed appropriate and cut into 1-minute flight segments. The 1-minute flights were then uploaded to YouTube as this would ensure that participants could view the video in a high-resolution. The YouTube videos were then embedded in the Qualtrics surveys.

Decision options were created using the previous aviation literature that used prospect theory (Goh & Wiegmann, 2001; O'Hare & Smitheram, 1995). The literature divides the types of decision options that can be presented to the participant into those which are tangible or intangible and those which are for "self" or "others." The decision was made to include both tangible gains for "self" and "others" in each of the decision option per frame to keep the decision options as equivalent as possible for all other facets (see Table 3.9). Decision options were reviewed in detail by the advisor. All decision options presented to the participants are available in the Appendix (see Appendix I).

Table 3.9

The Attributes Highlighted in the Framed Scenario Decision Options

Scenario	Frame	Risk-Seeking Attributes	Risk-Averse Attributes
1	None	None	None
2	None	None	None
3	Gain	• On-time arrival for payload • Next set of passengers/cargo will not be affected • You'll be able to exercise your skill in a more challenging environment	• Pleasant flight environment for passenger/cargo intact • Safe feeling for passengers/ safe cargo • Accident-free record will continue
4	Gain	• Passenger/company expectations met • Safe arrival is likely although uncertain • Passenger transportation demand record might outweigh discomfort	• Safe aircraft • Unharmed passengers/cargo • Passengers and company see your commitment to safety
5	Loss	• Unlikely that conditions are unsafe for landing • Avoid compensating late passengers • May cause company to have to compensate late passengers	• Late passengers/cargo • Passengers will have to be rescheduled/cancelled • Company disappointed in your abilities as a pilot
6	Loss	• Flight may have turbulence • Customers may feel unsafe • Company may consider your decision reckless	• Late passengers/cargo • Customers will be upset • Company will have to compensate customers

Experimental Task. At the beginning of the task, participants were provided with a paragraph that oriented them to the reason for their flight. Participants were told that they were remote UAM pilots in the New York City area, whose route was between the Helipad at John F. Kennedy International Airport (JFK) and Manhattan Helicopters Heliport. They were told that they would first be informed of their payload, altitude, airspeed, heading, the cloud level, visibility, precipitation, and wind speed. Next participants viewed a recorded flight that always began in the air in the cruise phase, between 1,000 AGL and 2,000 AGL and lasted for 1 minute. The recorded flight in the eVTOL aircraft had callouts presenting the heading, airspeed, distance to the destination site, altitude, and vertical speed (see Figure 3.2). After viewing the recorded video and clicking next, participants were presented with updated weather at the destination site and asked to make a decision as to whether they wished to continue to the destination or return to the departure site. Participants' decisions were either free of frame, presented as gain-framed, or presented as loss-framed.

Figure 3.2

Participants View of Recorded Flight

Each participant performed six scenarios in a row. Participants always began by performing two scenarios free of framing, followed by two gain-framed scenarios, and finally two loss-framed scenarios (see Table 3.10 for example of framed decision options). This order was used to control for any anchoring effects, specifically to avoid decision options free of framing from being anchored by a gain frame and to ensure that the gain frame decision options were not anchored by losses. The effects of loss frames have previously been found to linger longer than gain frames (Ledgerwood & Boydstun, 2014). Additionally, payload type was counterbalanced, for each set of framed scenarios (i.e., half of the participants had passengers onboard first and half had cargo onboard first). Counterbalancing was used to account for order effects (see Table 3.11 for counterbalancing).

Table 3.10

Example of Framed Decision Options with Cargo

Frame Type	Decision Options	
	Risk-Averse	**Risk-Seeking**
No Frame	Return to the departure site	Continue to the destination site
Gain Frame	Return to the departure site, this will ensure the aircraft is safe. Returning will also ensure amazon crates are intact. The amazon warehouse and your company will recognize your commitment to the safety of your cargo.	Continue to the destination site, the chances of a safe on-time arrival for the amazon crates aboard the aircraft although uncertain, is likely. Amazon's expectations will be met, and you will continue your exemplary record for meeting Amazon delivery demands.
Loss Frame	Continue to the destination site, where the chance that the flight conditions are unsafe for landing is very unlikely. The chances that the conditions cause Amazon crates to get damaged is also very unlikely. Continuing the flight may cause your company to have to compensate Amazon for damaged crates.	Return to the departure site, where late amazon crates will cause the company to have to cancel or reschedule the next Amazon deliveries, and this will impact the rest of the flights along your route. Your company will be disappointed in your inability to stay on schedule.

Note. All frames are presented in Appendix I

Table 3.11
Potential Counterbalance Orders for Frame and Payload Received by Participants

Order	No Frame		Gain Frame		Loss Frame	
	Scenario 1	**Scenario 2**	**Scenario 3**	**Scenario 4**	**Scenario 5**	**Scenario 6**
1	Cargo	Passenger	Cargo	Passenger	Cargo	Passenger
2	Cargo	Passenger	Cargo	Passenger	Passenger	Cargo
3	Cargo	Passenger	Passenger	Cargo	Cargo	Passenger
4	Cargo	Passenger	Passenger	Cargo	Passenger	Cargo
5	Passenger	Cargo	Cargo	Passenger	Cargo	Passenger
6	Passenger	Cargo	Cargo	Passenger	Passenger	Cargo
7	Passenger	Cargo	Passenger	Cargo	Cargo	Passenger
8	Passenger	Cargo	Passenger	Cargo	Passenger	Cargo

Procedure. Upon clicking the Qualtrics hyperlink, participants were presented with a short paragraph of text that (a) asked them to take the study on a laptop or desktop computer and (b) informed them that the study must be completed in one session. They were also provided with an identification number (ID) to enter at the end of the survey if they wished to be entered into the raffle or receive extra credit. Upon clicking the arrow on the page, Qualtrics randomization software randomly assigned them to one of the six counterbalanced scenario orders and presented the participant with the informed consent form. Participants were then asked whether they wished to participate and asked to indicate by selecting "I agree to Participate" or "I do not agree to participate." If they selected the latter, they were redirected to the end of the survey. If participants agreed to participate, they were presented with a study introduction that provided background on UAM and an overview the upcoming task including the purpose, what they would be doing, and the amount of time it would take to complete (See Appendix C). Next, they filled out demographic questionnaires that consisted of age, biological sex at birth, race, ethnicity, type of flight experience (Flight and UAS), level of flight experience (i.e., their highest certification level), number of flight hours, gaming experience and frequency, and whether they had taken the UAM course at Florida Tech. Upon completing the demographics section, participants were oriented to their role in the study (i.e., that of a remote UAM operator conducting flights to and from JFK and the Heliport). Participants were provided with an image of the route and an image of the display that included descriptors of the information that would be presented. Participants were told to pay attention, watch the videos, and instructed how to improve the quality of the video when viewing. At this point the task began. First, participants were presented with the weather at their destination including cloud level, visibility, precipitation, and wind (see Appendix J for weather information provided to participants). They were told to select next when they were done reviewing the information. Upon selecting next, they were presented with one of the simulated UAM flight recordings and information on how to select the highest quality viewing from the video settings. Upon finishing the video recording, participants could click into the next screen, where they were presented with the updated arrival weather and asked to select a decision to continue to the destination or return to the departure site that had no frame or was either gain or loss framed. Once the decision was made, the post-scenario questions were presented, including the continuous decision outcome measure and the NASA-TLX. Then participants repeated this process in their respective counterbalanced order for five more scenarios, answering the questions after each scenario. Once the participants finished all the scenarios, post-scenario questions, and the risk propensity scale, three items related to their experience with the weather were presented. Once completed, participants were asked to input the ID number they received and encouraged to reach out via the email provided on the flier if they had any questions.

Threats to Internal Validity

History. A history threat refers to any unanticipated event during the course of study, such as news, or cultural events that may impact the dependent variable. For example, a change in UAM policy that occurs mid data collection may impact participants' final decision and therefore the participants prior to this policy change are not equivalent to the participants after the change in policy. To control for this effect, UAM and AAM industry updates were monitored during the study and none emerged.

Selection. A selection threat is the result of dissimilar groups, leading to the outcomes of the study rather than the treatment. The current study utilized one group and each participant acted as his or her own control, therefore this was not a relevant threat.

Maturation. The maturation effect takes place when changes occur in the participants over time during the study such as fatigue that may impact the dependent variable. The total length of the current study was approximately 25 minutes, therefore it was determined that the time was not sufficient for a maturation threat to occur.

Selection-Maturation. The selection-maturation threat occurs when participants in different groups mature at different rates. This threat was not relevant to the current study as there was only one group.

Experimenter Effect. The experimenter effect refers to when different experimenters administer the treatment differently and/or the unintended influence that a researcher has on his or her research that can occur due to his or her interaction with participants or personal characteristics. The study was done via Qualtrics, no experimenters were present while the participants took the study. Further, all the participants got the same information with the exception of the counterbalancing, and responses were self-reported, therefore this threat was not relevant to the current study.

Testing Effect. The testing effect occurs when exposure to a pretest alters participants' performance on a posttest. In the context of the current study, the use of a repeated measures design wherein participants were performing scenarios with the same payload more than once, could have yielded a testing effect. To protect against this threat, counterbalancing of payload across participants was used. Additionally, other aspects such as weather and route descriptions were changed across scenarios. Further, to minimize any effects of anchoring produced by one frame to another, scenarios always began with no frame, gain frame, and finished with a loss frame.

Instrumentation. An instrumentation threat occurs when a change in the way the dependent variable is collected or measured occurs, may be due to the way the tests are administered or the use of different observers. The participants were provided with the same information, excluding the frame, payload manipulations, and counterbalancing. The same instruments were administered across all experiment scenarios, all data were input by the participant or collected by software.

Subject Effects. There are two types of subject threats that can occur when the participants' perception of the study impact their responses. One of the subject effects is the Hawthorne effect wherein participants act differently due to being observed and their group. The current study did not have a researcher present, however, participants may have responded differently as they knew their responses would be collected by the software and viewed by a researcher. The second subject effect is the John Henry effect, this occurs when the participant is aware of their group assignment and tries to outperform the other group. The John Henry effect is not relevant to the current study as there was only one group.

Statistical Regression. The statistical regression effect occurs when participants who score very high or very low on their pretest regress towards the mean on subsequent assessments. If one group has more participants who scored low in the pretest, the data may show that this group had more gains in the posttest than the other group when they did not. This threat was not relevant as there was only one group therefore participants served as their own control, and the design was not a pretest-posttest.

Location. The location threat relates to the physical location the data are collected in and the effects that multiple locations may have on the results. Due to the study being conducted via Qualtrics there was no way to control the location of the participants. The location threat was included in the limitation section of the current work.

Diffusion of Treatment. Communication between participants leading them to know details of the study that impact their performance or informing the control group of treatment information is diffusion. The current study utilized one group therefore all participants got all treatments.

Mortality. A mortality threat can occur if participants drop out during the study, leading to a more biased sample. This threat may have impacted the current study as the data of participants who were unable to complete the full study were not included in the data analysis. Readers are made aware of how the final sample came to be and what led to the exclusion of any data. Further, a comparison of demographics between those who did not complete the study and those who did is included in Chapter 4 and issues with mortality were included in the limitation section of the current work.

Treatment Verification and Fidelity. Treatment verification and fidelity refer to the extent to which the actual implementation of the study followed the planned study implementation (Shaver, 1983). Qualtrics and the video recordings were used to ensure that the administration of the independent variables were only different based on their respective levels and that the administration and implementation was the same regardless of the participant. All participants received the same background information and introduction. Further all data were collected via Qualtrics and then exported into a spreadsheet. Standardization of all verbiage outside of the manipulation and measures ensured treatment fidelity. Previous research and theory were heavily referenced to confirm that the independent variables used in the current study were appropriate to ensure ecological validity. Further, to ensure that both independent and dependent variables could be replicated, detailed descriptions of each variable are presented in Chapter 3.

Data Analysis

To examine the relationship between payload and the riskiness of weather-related decision-making, a sign test was performed using the two payloads and the dichotomous decision outcome. To examine the relationship between frame type and the riskiness of weather-related decision-making, a Friedman test was performed using the three frame types and the dichotomous decision outcome variable. A two-way MANOVA was conducted to examine the effects of payload type and framing, and any interaction between these two variables on the decision outcome continuous variable and decision time. Descriptives of all of the dependent variables are also presented. Finally, workload, risk propensity, and weather-related perceived risk were examined to see whether there was a relationship between individual's risk propensity, workload, and participant's levels of agreement on the continuous decision outcome variable. The results of these analyses are presented in both narrative and table forms in Chapter 4.

Chapter 4

Results

Introduction

The following chapter presents the results of the current study. The first section presents the preliminary analysis including the outlier analysis, how missing data were handled, and assumption checking associated with a multivariate analysis of variance (MANOVA). The second section presents a summary of the descriptive statistics associated with the dependent variables of categorical-decision outcome, continuous decision outcome, and decision time. The third section presents the results of the inferential statistics. This includes two non-parametric tests conducted on the categorical variables: a Friedman test examining differences across the three frame types and the sign test examining differences across the two payload types. Also included is a repeated measures MANOVA examining impacts of framing and payload on the continuous variables. The results of the multivariate omnibus analysis and univariate analyses are presented. The fourth section presents the results of hypothesis testing that corresponds to the research questions presented in Chapter 1.

Preliminary Analysis

Missing Data

A total of 98 participants accessed the survey. However, of those, 15 were identified as spam or fraudulent submissions by online bots. Therefore, these data were removed leading to a sample size of 83. Further, 19 of the participants who accessed the survey ended it after only completing the demographics section prior to the task. These data were removed from the sample leading to a sample size of 64. Six participants terminated the survey before the third scenario and therefore only received no-frame decision options. These data were removed from the data set as they never received the treatment, leading to a sample size of 58. Two participants completed less than 70% of the survey, but did not complete all the scenarios, and skipped sections of the survey. The decision was made to remove them as 30% of their data were missing, leading to 56 participants. Finally, two participants completed the entire survey but when examining their demographics, it was found that they had inserted a 0 for their flight hours (i.e., had never conducted a flight), therefore their data was removed. This is because participants must have flown at least one flight to participate. This resulted in a total of 54 participant data sets. To ensure that the data that were omitted did not represent a different subset of the population, the demographics of the omitted data points were collected, excluding the data identified as spam and those which did not meet the inclusion criteria. Demographics of the omitted participants were very similar to the participants included in the dataset, some of the demographics are presented below in Table 4.1. When examining the scores on the continuous decision outcome variable, four participants were missing scores for one of their continuous decision outcomes. Due to the low amount of missing data, mean computations for each of the three columns in which the missing data came from were derived and inserted in place of the four missing data points.

Table 4.1

Comparison of Demographics Between Sample Data and Omitted Data

Demographics	Final Sample	Omitted Data[a]
Age		
M	29.57	32.85
SD	15.19	17.33
Range	18-75	18-66
Biological Sex at Birth		
Male	45	14
Female	6	3
I prefer not to Say	1	0
Race		
White	29	8
Black or African American	4	5
American Indian or Alaska Native	0	_
Asian	12	3
Native Hawaiian or Pacific Islander	0	_
Other[a]	7	1
Ethnicity		
Hispanic or Latino	4	1
Not Hispanic or Latino	42	17
Other[b]	5	0
UAM Class Experience		
Yes	1	0
No	51	15
Type of Flight Experience[c]		
Manned Fixed-wing aircraft	49	15
Helicopter	6	2
UAS	10	3

Note. Omitted data sample n = 27. [a]omitted data: 14 data points were missing for age, 10 data points were missing for gender, 11 data points missing for race.

Outlier Analysis

Outliers are data cases that exhibit very high or low scores that can represent either contaminated data or extreme cases. In the case of contaminated data, this can occur when data has been incorrectly entered or the result of an error. In extreme cases, this can occur if participants exhibit an abnormal case such as a participant with vastly more flight experience than others. Jackknife distances were calculated to check the dataset for outliers. The analysis revealed seven outliers. These outliers were visually inspected, and were all determined to be rare or extreme cases. One of the outliers took 292 seconds to make a decision whether to continue or return for one of the scenarios. This was more than 5 standard deviations from the mean of 34 seconds. Upon further inspection, it far exceeded this participant's other decision times, and therefore the data point was removed as it may have been the result of a non-attentive participant. One outlier took 345 seconds to decide whether to continue or return in one of the scenarios. This was more than 4 standard deviations from the mean of 36 seconds. Upon further inspection, this time far exceeded this participant's other decision times, and therefore the datapoint was removed as it may have been the result of a non-attentive participant. The other five outliers were located in a cluster. One participant took over 301, 321, and 213 seconds to decide whether to continue or return in three separate scenarios. These times were more than 4, 4, and 3 standard deviations from the means of 39, 36, and 34 seconds, respectively. Although these decision times were high, they were consistent with this participant's other decision times and therefore the case was not removed. Another participant took 319 seconds to decide whether to continue or return in one of the scenarios. This decision time was more than 4 standard deviations from the mean of 39 seconds. However, on further inspection the participant had other data points with elevated decision times, therefore this case was not removed. Another participant took 115 seconds to decide whether they wanted to continue or return in one of the scenarios. This was less than 2 standard deviations from the mean of 36 seconds. Further inspection revealed that they had other decision times that were similar and therefore this case was not removed. Another participant took 117 seconds to decide whether to continue or return in the first scenario. This was 4 standard deviations from the mean of 26 seconds. However, on further inspection they had another decision time that was relatively high and therefore, this case was not removed. Based on this examination, two outliers out of the 54 participants in the sample were removed resulting in 52 participants being included in further analyses.

Assumptions

Multicollinearity. One assumption with multivariate analyses is that each variable has the potential for a unique contribution to the explained variance. To ensure this, variables must not be highly correlated. To assess the relationship between the variables, bivariate correlations were analyzed between the dependent variables. Correlation coefficients of $r > .8$ are considered problematic, ideally, the correlation between the dependent variables should be between .3 and .8 (Pallant, 2011). It was revealed that all variables exhibit correlation coefficients below 0.68, and therefore it was determined multicollinearity was not an issue.

Homogeneity of Covariance. Mauchly's test of sphericity was utilized to examine the homogeneity of variance assumption. Sphericity was not significant for the influence of framing on decision time, $p = .373$; however, it was significant for the framing's influence on the continuous decision outcome variable, $p = .011$. Therefore, when examining the continuous decision outcome variable the Greenhouse-Geisser correction was utilized. Mauchly's test of sphericity was significant for the interaction effect between frame and payload's influence on decision time, $p < .001$ but not for the continuous decision outcome variable, $p = .872$, therefore when examining the decision time variable the Greenhouse-Geisser correction was utilized.

Equal Variances. Levene's test was satisfied for all of the time dependent variables but not all of the continuous decision outcome variables. However, Stevens (2001, p.268) notes, "…the *F* statistic is robust against heterogeneous variances when the group sizes are equal." The group sizes were equal for each condition of the dependent measure given the within-subjects nature of the study.

Therefore, noncompliance with the equal variance assumption did not preclude me from continuing with my primary analysis.

Normality. The normality assumption is concerned with the error of the residuals being normally distributed for each of the DVs. It was found that neither decision times nor scores of the continuous decision outcome were normal. However, Mordkoff (2016, p. 1) has shown that statistical tests with sample sizes larger than $N = 30$ are robust against data that are not normal. Further, Stevens (2001, p.262) states, "…the sampling distribution of *F* is only slightly affected, and therefore the critical values when sampling from normal and non-normal distributions will not differ by much". Therefore, the noncompliance of normal distributions did not preclude me from continuing with the primary analysis.

Independence. The independence assumption is concerned with the observations of each DV being independent of one another. The reader should note that although each score is from the same individual (which infers dependency), the scores within each treatment condition are independent because they are from different individuals. Given that none of the scores were dependent on each other, the independence assumption was met.

Summary of Preliminary Analyses. Following the removal of fraudulent submissions, those who did not partake in all of the decision-making tasks, survey takers who did not meet the minimum criteria to participate, and the two outliers, the total sample size included $N = 52$ participants. The few instances in which missing data occurred in the decision time were replaced with mean computation. Equal variance and normality assumptions were violated but should not affect the primary analyses due to the robustness of the F test.

Supplemental Analysis

To determine whether there was a relationship between individual's risk propensity, workload, weather-related perceived risk, and participant's levels of agreement on the continuous decision outcome variable (scores are summarized below in Table 4.2). A bivariate correlation between risk propensity scores and the continuous decision outcome variable per frame and payload were examined. Risk propensity scores and weather-related perceived risk were significantly correlated with the continuous decision outcome variable. However, workload was not. When risk propensity was added as a covariate it was not a significant covariate, so it was left out of the primary analyses. Weather-related perceived risk scores for each weather type (i.e., rain, wind, visibility/clouds) were added as covariates and none were significant covariates, therefore they were left out of the primary analyses.

Table 4.2
Summary of Risk Propensity, Workload, and Weather-Related Perceived Risk Scores

Potential Covariates	*M*	*SD*	*Range*
Risk Propensity[a]	4.08	0.69	2.85
Workload[b]	53	13.69	56.66
Perceived Risk of Wind[c]	2.01	0.51	2
Perceived Risk of Rain[c]	1.88	0.52	2
Perceived Risk of Cloud/Visibility[c]	2.39	0.67	2

Note. $N = 52$.
[a]The Risk Propensity scale is a measure of an individual's willingness to take risk. Scores could range from 7 to 63.
[b]The NASA-TLX is a measure of mental workload. Scores could range from 6 to 120, with higher scores representing higher mental workload.
[c]Each Weather-related perceived risk score could range from 1 to 3.

Descriptive Statistics

The descriptive statistics presented in this section are relative to the resulting $N = 52$ participants retained in the data set. After each participant viewed each of the six recorded flight scenarios, they were asked to make a weather-related decision as to whether to continue to the destination site (risk-seeking decision outcome) or return to the departure site (risk-averse decision outcome), resulting in 312 participant decisions.

Tables 4.3 - 4.5 present the number and percentage of participant decisions to continue or return, per condition. The descriptive statistics associated with each condition were derived by summing the scenarios for each of the two scenarios per framing conditions or each of the three scenarios per payload conditions.

As summarized in Table 4.3, participants continued more frequently in the cargo condition (*n* = 87, 55.77%) than they returned (*n* = 69, 44.23%). The reverse was found for the passenger condition, participants more frequently made the decision to return (*n* = 84, 53.85%) than they continued (*n* = 72, 46.15%).

Table 4.3
Number (n) and Percentage of Risky Weather-Related Decisions per Payload Condition

Condition	Risk-Averse		Risk-Seeking	
	n	**%**	***n***	**%**
Passenger	84	53.85%	72	46.15%
Cargo	69	44.23%	87	55.77%

Note. N = 52, participants who made = 312 total decisions and 3 decisions per payload condition.

As summarized in Table 4.4, in the no-frame condition participants more frequently made the decision to continue (risk-seeking: *n* = 67, 64.42%) than to return (risk-averse: *n* =37, 35.58%). This was also the case in the loss-frame condition, in which participants also more frequently made the decision to continue (risk-seeking; *n* = 57, 54.81%) than to return (risk-averse; *n* = 47, 45.19%). However, in the gain frame condition, participants more frequently made the decision to return (risk-averse: *n* = 69, 66.35%) than to continue (*n* = 35, 33.65%).

Table 4.4

Number (n) and Percentage of Risky Weather-Related Decisions per Framing Condition

Condition	Risk-Averse		Risk-Seeking	
	n	***%***	***n***	***%***
No Frame	37	35.58%	67	64.42%
Gain Frame	69	66.35%	35	33.65%
Loss Frame	47	45.19%	57	54.81%

Note. N = 52, participants who made = 312 total decisions, 2 decisions per framing condition.

As summarized in Table 4.5, in the no-frame condition, when passengers and cargo were onboard, participants more frequently made the risk-seeking decision. Framing effects were stronger for cargo (risk-seeking: n = 37, 71.15%) compared to passengers (continue: n = 30, 57.69%). In the gain-frame condition, when passengers were on board the reverse was found, as framing effects were stronger for passengers than cargo. Participants more frequently made the decision to return with passengers (risk-averse: n = 37, 71.15%) than when cargo was onboard (risk-averse: n = 32, 61.54%). In the loss frame, framing effects were stronger for cargo payload (risk-seeking: n = 30, 57.69%) compared to passenger payload (risk-seeking: n = 27, 51.92%).

Table 4.5

Number (n) and Percentage (%) of Risky Weather-Related Decisions per Framing and Payload Conditions

Condition	Risk-Averse Return		Risk-Seeking Continue	
	n	**%**	***n***	**%**
No Frame				
Passenger	22	42.31%	30	57.69%
Cargo	15	28.85%	37	71.15%
Gain Frame				
Passenger	37	71.15%	15	28.85%
Cargo	32	61.54%	20	38.46%
Loss Frame				
Passenger	25	48.08%	27	51.92%
Cargo	22	42.31%	30	57.69%

Note. $N = 52$ participants who made $n = 312$ decisions.

For each scenario, participants' decision time was captured. Participants were also asked to rate their level of agreement with the decision to continue or return on a 5-point Likert scale (continuous decision variable). Tables 4.5 - 4.7 present the means and standard deviations associated with the continuous decision outcome variable and the decision time variable.

As summarized in Table 4.6 below, on average, when passengers were the payload there was less than a 1 second difference in decision time ($M = 29.56$, $SD = 3.55$) compared to when cargo was the payload ($M = 30.36$, $SD = 4.26$). Furthermore, on average, the cargo had a level of agreement more consistent with "neither agree to continue or divert" ($M = 3.04$, $SD = .12$) whereas the passenger payload had a more risk-averse level of agreement ($M = 2.74$, $SD = .13$).

Table 4.6
Mean and Standard Deviations of Decision Times and Continuous Decision Outcome Scores per Payload Condition

	Decision Time in seconds		Continuous Decision Outcome	
Condition	***M***	***SD***	***M***	***SD***
Passenger	29.56	3.55	2.74	.13
Cargo	30.36	4.26	3.04	.12

Note. N = 52, participants who made = 312 total decisions and 3 decisions per payload condition.

As summarized in Table 4.7, on average, in the no-frame condition participants took less time to make a decision (M = 24.43, SD = 2.27) compared to the gain-frame condition (M = 35.17, SD = 5.15) and loss-frame condition (M = 30.28, SD = 5.41). Furthermore, on average, the level of agreement for the no-frame condition was more consistent with "neither agree to continue or divert" (M = 3.16, SD = .13) compared to the gain-frame condition that was more consistent with "agree to divert" (M = 2.49, SD = .15). However, on average, the loss-frame condition was more consistent with "neither agree to continue or divert" (M = 3.01, SD = .12) like the no-frame condition.

Table 4.7
Mean and Standard Deviations of Decision Times and Continuous Decision Outcome Scores per Framing Condition

Condition	Decision Time in seconds		Continuous Decision Outcome	
	M	***SD***	***M***	***SD***
No Frame	24.43	2.27	3.16	.13
Gain Frame	35.17	5.15	2.49	.15
Loss Frame	30.28	5.41	3.01	.12

Note. N = 52, participants who made = 312 total decisions and 2 decisions per frame condition.

As summarized in Table 4.8, on average, in the no-frame condition, passenger payload resulted in longer decision times (*M* = 27.37, *SD* = 24.09) compared to cargo payload (*M* = 21.49, *SD* =17.72). The reverse was found in gain frames, on average, in the gain-frame condition, when passengers were the payload, decision times were shorter (*M* = 30.29, *SD* = 26.39) compared to when cargo was the payload (*M* = 40.05, *SD* =59.11). Yet, when loss-framed information was presented, on average, passengers payload led to minimally higher decision times (*M* = 31.01, *SD* = 47.23) compared to cargo payload (*M* = 29.55, *SD* =35.95).

When examining the results of the continuous decision outcome variable, on average, levels of agreement to continue or return in the no-frame condition with passengers as payload was narrowly more consistent with "agree to divert" (*M* = 2.98, *SD* = 1.24) than cargo as payload, that was more consistent with "neither agree to continue or divert" (*M* = 3.35, *SD* = 1.15). In the gain-frame condition, with passengers as payload the same trend emerged, as levels of agreement were more consistent with "agree to divert" (*M* = 2.35, *SD* = 1.19) than with cargo as payload (*M* = 2.63, *SD* = 1.25). In the loss-frame condition, on average, passenger payload levels resulted in responses more consistent with "agree to divert" (*M* = 2.88, *SD* = 1.28) than cargo payloads, which resulted in responses more consistent with "neither agree to continue or divert" (*M* = 3.13, *SD* = 1.12).

Table 4.8

Mean and Standard Deviations of Decision Times and Continuous Decision Outcome Scores per Condition

	Decision Time in seconds		Continuous Decision Outcome	
Condition	***M***	***SD***	***M***	***SD***
No Frame				
Passenger	27.37	24.09	2.98	1.24
Cargo	21.49	17.72	3.35	1.15
Gain Frame				
Passenger	30.29	26.39	2.35	1.19
Cargo	40.05	59.11	2.63	1.25
Loss Frame				
Passenger	31.01	47.23	2.88	1.28
Cargo	29.55	35.95	3.13	1.12

Note. $N = 52$, participants who made = 312 total decisions.

Inferential Statistics

Overview

To facilitate statistical analysis, the dichotomous decision outcome variable for each of the participants (i.e., whether they decided to continue to the destination site or return to the departure site) was recoded in the following manner. First, the variable was coded 0 (return) or 1 (continue) for all six trials that each participant completed. Next, variable values were averaged across subcategories to identify the average number of decision outcomes to continue versus decision outcomes to return across subcategories of passenger and cargo, (i.e., if participants continued in all three scenarios they received a score of 1, if they continued in two scenarios they received a score of .67, if they continued in one scenario they received a score of .33, and no continues, a score of 0). This process was repeated with no frame, positive frame, negative frame (if participants continued in both scenarios, they had a 1, if they continued in one scenario they received a .5, if they had no continues, a 0). The following paragraphs will cover the results of Sign test, Friedman test, and finally the MANOVA.

Non-Parametric Tests

Sign Test. Due to the categorical nature of the data, an exact sign test, which is the nonparametric equivalent of a paired samples t-test, was used to compare the differences between the categorical-decision outcome variable that was used to measure the riskiness of the weather-related decision for the two payload types. The exact sign test was used to determine whether there was a median difference between participants' decision outcomes associated with passenger and cargo payload. Results indicated that out of the 52 participants, 23 participants had higher levels of continue to the destination site when they had cargo as the payload compared to passenger as the payload, 17 participants had equal levels of continue to the destination site in the scenarios with cargo as the payload compared to passengers as the payload, and 12 participants had lower levels of continue to the destination site with cargo as the payload compared to passengers as the payload. The exact sign test, which uses a binomial distribution calculation to determine significance indicated that the difference between the medians was not statistically significant (p =.091).

Friedman Test. To examine if there was a difference across the three frame types, a non-parametric Friedman test of differences among repeated measures was conducted on the decision outcome variable for all three frames. Due to the categorical and ordinal nature of the data (i.e., a participant could decide to continue in neither scenario, continue in one scenario, or continue in two scenarios), a Friedman test, which is the equivalent of the ANOVA for ordinal data, was conducted to compare the mean ranks between the decision outcome variable that was used to measure the riskiness of the weather-related decision with each of the three frame conditions. The mean ranks indicated that for the 52 participants, the continue to destination site response increased from the scenarios with gain-framed decision options (mean rank = 1.58) to scenarios with loss-framed decision options (mean rank = 2.09), and scenarios with no-frame decision options (mean rank = 2.34). The percent increase in average number of continues to the destination site (risk-seeking behavior) from gain-framed decision options (M = .337, SD = .379), to loss-framed decision options (M = .548, SD = .360), and no-frame decision options (M = .644, SD = .333), was statistically significance, $\chi2(2)$ =

22.205, $p < .001$. Post hoc analysis with Wilcoxon signed-rank tests was conducted with a Bonferroni correction applied, to examine if the differences between frames were significant. The resulting significance level was set at $p < 0.017$. There were significant differences between no frame and gain frame ($Z = -4.117$, $p < .001$) as well as gain frame and loss frame ($Z = -3.563$, $p < .001$) in the categorical decision outcome variable. There was no significant difference between no frame and loss frame ($Z = -1.617$, $p = .106$).

Parametric Test

MANOVA. A 2 (cargo vs. passenger) x 3 (no frame vs. gain frame vs. loss frame) repeated measures MANOVA was conducted on the continuous decision outcome variable and decision time variable. At the multivariate level, the effect of payload on the combined dependent variables was not statistically significant, $F(2, 50) = 2.803$, $p = .070$; $\eta^2 = .101$. The effect of frame on the combined dependent variables was statistically significant, $F(4, 48) = 7.303$, $p < .001$; $\eta^2 = .378$. The interaction effect between payload and frame on the combined dependent variables was not statistically significant, $F(4, 48) = 0.632$, $p = .642$; $\eta^2 = .050$. Although there was not a statistically significant multivariate effect of payload or a significant interaction at the multivariate level, at the preset $\alpha = .05$ if the readers are willing to accept an $\alpha = .075$, the univariate results can be examined. Going with that assumption the univariate results for frame and payload were examined. (see Table 4.9).

Table 4.9

Repeated Measures MANOVA Multivariate Results

Variable	*F* ratio	*df*	η2
Payload	2.803	2, 50	.101
Frame	7.303***	4, 48	.378
Payload x Frame	0.632	4, 48	.050

Note. $N = 52$

*$p < .05$. **$p < .01$. ***$p < .001$.

Main Effects. At the univariate level, if the readers are willing to accept an α = .075, the main effect of payload type on decision time was not significant, F(1, 51) = .128, p = .72. However, the main effect of payload on the continuous decision outcome variable, was significant, F(1, 51) = 5.66, p = .021. On average, when participants experienced scenarios with passengers onboard, they rated their decision as "Agree to Divert" (M = 2.74). Whereas, when participants experienced scenarios with cargo onboard, on average they rated their decision as "Neither Agree to Divert or Continue" (M = 3.04). Pairwise comparisons reveled that the mean group differences in levels of agreement were statistically significant between passenger and cargo, p < .05.

At the univariate level, the main effect of framing on decision time was significant, $F(2, 102) = 3.105$, $p = .049$. Gain-frame decisions took an average of 11 seconds longer than no-frame decisions. Pairwise comparisons revealed that the mean group differences in decision times between gain frames and no frames were significant, $p = .009$. Gain-framed decisions were an average of 5 seconds longer than the loss-frame decisions. When examining pairwise comparisons, this difference in time was not statistically significant. Loss-frame decisions took an average of 6 seconds longer than no-frame decisions. Pairwise comparisons revealed that the difference between mean group differences were not statistically different.

At the univariate level, the main effect of framing on the continuous decision outcome variable was also significant, $F(1.716, 97.990) = 12.054$, $p < .001$. On average, when participants were presented with the gain-frame condition they rated their decision outcomes as “Agree to Divert” ($M = 2.49$). On average, when they were presented with the no-framed and loss-framed conditions they rated their decision more consistently with “Neither Agree to Divert or Continue” ($M = 3.16$, $M = 3.01$, respectively). Pairwise comparisons revealed that the mean group differences in levels of agreement were statistically significant between gain-framed scenarios and no-frame scenarios, $p < .001$. Additionally, the mean group differences in levels of agreement were statistically significant between gain-framed decision options and loss-framed decision options, $p < .001$. However, the mean group differences between loss-framed scenarios and no-frame scenarios were not statistically significant, $p = .229$ (see Table 4.9.)

If the readers are willing to accept an α = .075, when examining the interactions between the independent variables and the continuous decision outcome variable the following was found. The interaction between payload and frame for decision time was not significant, $F(1.55, 78.97) = 1.8$, $p = .18$ (see Figure 4.9). The interaction between payload and frame for the continuous decision outcome variable was also not significant, $F(2, 102) = .086$, $p = .92$ (see Figure 4.10.)

Table 4.9

Repeated Measures MANOVA Univariate Results

Variable	**MANOVA**		
	***F* ratio**	***df***	**η2**
Payload			
Decision Time	.13	1,51	.002
Decision Outcome[a]	5.66*	1,51	.100
Frame			
Decision Time	3.11*	2,102	.057
Decision Outcome[a]	12.05***	1.716,87.515	.191
Payload x Frame			
Decision Time	1.80	1.548,78.967	.179
Decision Outcome[a]	.08	2,102	.918

Note. $N = 52$. The decision option length was not held constant across scenarios and therefore, decision time should be interpreted with caution.

*$p < .05$. **$p < .01$. ***$p < .001$.

Figure 4.1.

Decision Time by Condition

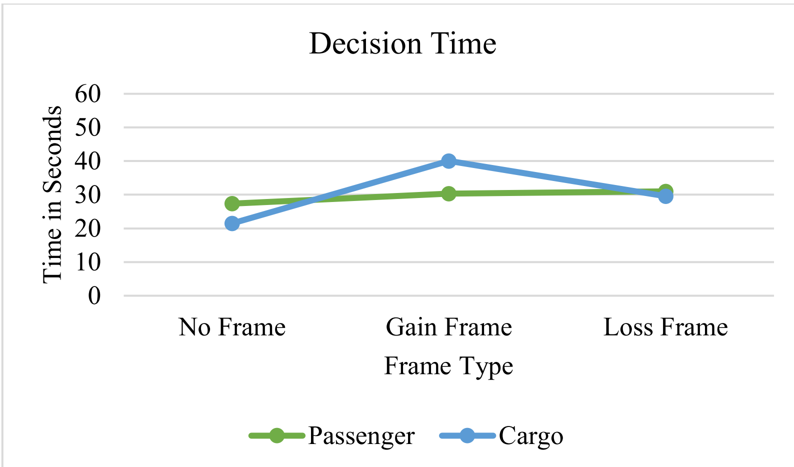
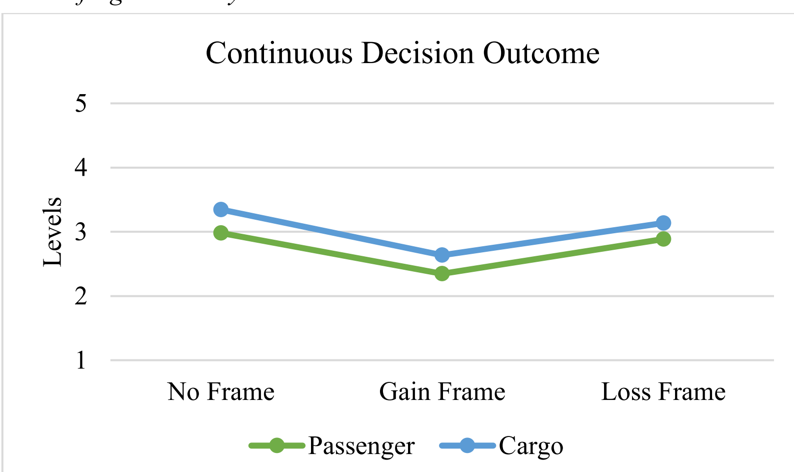


Figure 4.2.

Level of Agreement by Condition



Note: Continuous Decision Outcome levels were: 1 = highly agree to divert, 2 = agree to divert, 3 = neither agree to continue or divert, 4 = agree to continue, 5 = highly agree to continue.

Results of Hypothesis Testing

The research questions and research hypotheses for the current study were presented in Chapter 1. The research hypotheses are restated in null form within this section for testing purposes. Each hypothesis is presented along with the corresponding decision to reject or fail to reject.

Null hypothesis 1a: Independent of frame type, there will be no significant effect of payload type on the riskiness of weather-related decision-making as indicated by the categorical measure of decision outcomes. As was indicated by the sign test there was no significant effect of payload type on the riskiness of weather-related decision-making. Therefore, Hypothesis 1a was not rejected.

Null hypothesis 1b: Independent of frame type, there will be no significant effect of payload type on the decision outcome measured by the level of agreement decision outcome variable. The results of the MANOVA were not significant at the preset alpha level of .05, however, going with the assumption that the readers are willing to accept an $\alpha = .075$, there was a significant effect of payload type on the level of agreement decision outcome variable at the univariate level. That is, in scenarios in which the payload was passengers, decisions were more consistent with, “Agree to Divert” whereas in scenarios where the payload was cargo, decisions were more consistent with, “Neither Agree to Divert or Continue”. Therefore, Hypothesis 1b was rejected.

Null hypothesis 1c: Independent of frame type, there will be no significant effect of payload type on the decision time outcome variable. As was discovered by the MANOVA, there was not a significant effect of payload type on the decision time variable at either the multivariate or the univariate level. Therefore, Hypothesis 1c was not rejected.

Null hypothesis 2a: Independent of payload type, there will be no significant effect of frame on the riskiness of weather-related decision-making as indicated by the categorical measure of decision outcomes. As was discovered by Friedman’s test, there was a significant effect of frame on the riskiness of weather-related decision-making. The differences in medians by frame were statistically significant. Therefore, Hypothesis 2a was rejected.

Null hypothesis 2b: Independent of payload type, there will be no significant effect of frame on the continuous decision outcome measured by the level of agreement decision outcome variable. As was discovered by the MANOVA, there was a significant effect of frame on the continuous decision outcome variable. The differences in levels of agreement were statistically significant. Therefore, Hypothesis 2b was rejected.

Null hypothesis 2c: Independent of payload type, there will be no significant effect of frame on the decision time outcome variable. As was indicated by the MANOVA, there was a significant effect of frame on the decision time variable. The differences in time were statistically significant. Therefore, hypothesis 2c was rejected.

Null hypothesis 3a: There will be no significant effect of the interaction between payload type and frame on the decision outcome measured by the level of agreement decision outcome variable. As was indicated by the MANOVA, there was not a significant interaction between payload type and frame for the continuous decision outcome variable at the multivariate or the univariate level. Therefore, Hypothesis 3a was not rejected.

Null hypothesis 3b: There will be no significant effect of the interaction between payload type and frame on the decision time outcome variable. As was indicated by the MANOVA, there was not a significant interaction between payload type and frame on the decision time variable at the multivariate or the univariate level. Therefore, Hypothesis 3b was not rejected.

Chapter 5

Conclusions Implications and Recommendations

Summary of the Study

The purpose of the current research study was two-fold. First, the study examined the effect of payload type on weather-related decision-making in a simulated UAM environment. Payload type consisted of whether there were passengers or cargo aboard the aircraft. Second, the proposed study examined whether framing information using prospect theory (Kahneman & Tversky, 1979) could influence weather-related decision-making process in a simulated UAM environment. Framing consisted of whether decision options were framed in terms of gains (positive outcomes), losses (negative outcomes), or no frame (no outcomes provided only decision options). Weather-related decision-making was examined using three dependent variables: dichotomous decision outcome variable, continuous decision outcome variable, and decision time. The study used a within-subjects repeated measures approach, which was determined to be the best approach to answer the research questions. The order of payload was counterbalanced, and frame type was ordered by no frame, gain frame, and loss frame, to mitigate order effects. This approach was used to control for any anchoring effects of payload and frame type.

The target population for the proposed study was pilots who have operated a fixed-wing aircraft, helicopter, or remotely-operated aircraft pilots. The target population is representative of future UAM pilots as they have knowledge of the proposed UAM airspace and experience flying smaller aircraft at lower altitudes (13,000 - 15,000 AGL for aircraft and up to 400 ft AGL for drones). Further, this population has been identified by the literature as those possessing the most similar certificate to future UAM operations.(Goodrich & Theodore, 2021). Data were collected via Qualtrics survey software. A study flier that included a link to the Qualtrics survey was distributed via social media, bulletin boards in Florida Tech's COA, aviation newsletters, and word of mouth. Utilizing convenience sampling and a snowball approach, the sample size obtained was $N = 98$. After performing preliminary data analyses, the final sample consisted of $N = 52$ participants. The demographic breakdown of the sample is presented in Chapter 3 (Table 3.2). The measures consisted of (a) a dichotomous decision outcome variable, (b) continuous decision outcome variable (c) decision time measured using Qualtrics survey software, (d) workload captured using the NASA-TLX, (e) risk propensity captured using the Risk Propensity scale, (f) and perceived risk associated with weather measured by the researcher-developed weather-related perceived risk measure. The reliability and validity of these measures are presented in Chapter 3.

Summary of Findings

A total of 98 participants accessed the survey. After removing 15 cases points due to being identified as fraudulent submissions, 19 participants who only completed the demographics section, eight participants who did not complete the full survey, and two for not having any flight hours, the final number was 54. The dataset of 54 participants was then screened for outliers leading to a final data set of $N = 52$. Two non-parametric tests were performed on the dichotomous decision outcome variable: the sign test and Friedman test. The sign test, used to determine whether there was a median difference between participants' decision outcomes associated with passenger and cargo payload, was not significant. The Friedman test, used to examine if there was a difference between the three frame types, was statistically significant. Further, a 2x3 within subjects repeated measures MANOVA was conducted on the continuous decision outcome variable and decision time. At the multivariate level, the effect of payload was not statistically significant, the effect of frame on the combined dependent variables was statistically significant, and the interaction effect was not significant, at the .05 level. However, going with the assumption that the reader was willing to accept an alpha of .075, payload was significant (see Table 5.1.) The results of the Risk Propensity scale, the NASA-TLX, and weather-related perceived risk scores were examined as covariates and none were significant covariates and were therefore not included in the primary analysis. The following section outlines a brief summary of the primary analysis.

Table 5.1

Summary of Hypotheses Tests Results (α = .05)

Null Hypothesis[a]		Decision
1a	There will be no significant effect of payload type on the riskiness of weather-related decision-making as indicated by the categorical measure of decision outcomes	Failed to Reject
1b	There will be no significant effect of payload type on the decision outcome measured by the level of agreement decision outcome variable	Failed to Reject for *(α = .05)* Rejected for *(α = .075)*
1c	There will be no significant effect of payload type on the decision time variable	Failed to Reject
2a	There will be no significant effect of frame on the riskiness of weather-related decision-making as indicated by the categorical measure of decision outcomes	Rejected
2b	There will be no significant effect of frame on the continuous decision outcome measured by the level of agreement decision outcome variable	Rejected
2c	There will be no significant effect of frame on the decision time variable	Rejected
3a	There will be no significant interaction between framing and payload type on the decision outcome measured by the level of agreement decision outcome variable	Failed to Reject
3b	There will be no significant interaction between framing and payload type on the decision time outcome variable	Failed to Reject

Note. $N = 52$.

[a]Hypotheses were tested using a sign test with a categorical DV of decision option, Friedman test with a categorical DV of decision option, and repeated measures MANOVA strategy with continuous decision option and decision time as the DVs.

Conclusions and Inferences

In the following section, the findings from the study are presented and discussed relative to the research questions and terms defined in Chapter 1. Each section describes the results related to the corresponding research questions, along with interpretations of those findings in the context of the research settings. Plausible explanations for the findings are also presented.

Research Question 1: What is the effect of payload type on the riskiness of weather-related decision-making?

Three measures were used to answer the first research question. The first measure was the categorical-decision outcome and it was examined using the sign test. The sign test revealed no significant effect of payload on the riskiness of weather-related decision-making as measured by the comparison of the decision to continue (risk-seeking) or return (risk-averse). One plausible explanation for the lack of significant results is that the level of utility perceived by the participants could have been similar for the two payloads. That is, participants may have assigned the same utility to both payloads as the decision outcomes may have felt similar in risk. Given that pilots were asked to imagine they were remotely piloting the aircraft, physical harm to themselves was not in the equation. Further the scenarios did not elaborate greatly on the payloads (e.g., how many humans, what type of cargo) to ensure that the decision options were not skewed in the favor of either payload.

Each decision option, regardless of payload, had consequences that included both tangible gains or losses for the decision maker and the payload (e.g., a tangible gain associated with passengers onboard would be a safe passenger and a tangible gain associated with the cargo would be safe packages). This decision was made based on the literature (O'Hare & Smitheram, 1995, & Goh & Weigmann, 2001) to keep the decision options as equivalent as possible for all other facets to ensure that the only difference was in the payload. However, this may have led to the participants only focusing on those tangible outcomes rather than the full gamut of outcomes that could result from the decision (intangible losses and gains, social approval, and disapproval).

Another plausible explanation for the results of the categorical-decision outcome is related to the use of a nonparametric test. Sign tests are less efficient than parametric tests, require large datasets, and stronger evidence to reject a null hypothesis (Kaur & Kumar, 2015). When examining the frequency table results of the paired differences for the sign test, almost double the number of participants had a higher amount of continues in scenarios with cargo onboard compared to passengers (n = 23) than participants who had a higher amount of continues for when they had passengers compared to cargo onboard (n = 12). However, the results were not significant. Further when examining the results of the descriptive statistics (see Table 4.1) related to the number of risk-seeking decisions (i.e., continuing to the destination) versus risk-averse decisions (i.e., returning to the departure) by each payload condition, more risky weather-related decisions were made with cargo (n = 87, 55.77%) compared to passengers (n = 72, 46.15%). Although, prospect theory supports that higher utility (passengers) leads to risk-seeking, there are logical explanations for the results found. One plausible explanation for the results is that pilots are trained to yield a high level of safety, in general, due to both the number of passengers and extremely expensive aircraft in their care. Therefore, participants made more risk-averse decisions when passengers were onboard compared to cargo to ensure that they were safe.

The second test used to examine the effect of payload on the riskiness of weather-related decision-making was the repeated measures MANOVA on decision time and the continuous decision outcome variable. The repeated measures MANOVA was not significant at the preset alpha of .05, however, with the assumption that the reader is willing to accept an alpha of .075, the univariate level analyses were examined. At the univariate level, decision time was not statistically significant between payload types, however, the continuous decision outcome variable was significant. On average, when passengers were payload participants rated their decision as “Agree to Divert” (risk-averse). Whereas on average, in scenarios with cargo as the payload, decisions were rated as "Neither Agree to Divert or Continue." The plausible explanations will be discussed relative to decision time first, followed by the continuous decision outcome variable. One plausible explanation for the insignificant results at the preset alpha of .05, is the sample size. When examining the power for payload, it was .52. This indicated that the sample size may have been too low. Theory suggests the results should be significant, therefore the lack of significance may have been due to a type 2 error.

A plausible explanation for the results relative to decision time at an α = .075 is that payload does not impact decision time for pilots. That is, pilots are trained of the importance of quick decision-making and therefore, time may be a factor that is not impacted by simply the presence of payload but rather a combination of factors. Flight is a time sensitive environment and therefore payload may not be a factor itself that leads to longer decision times and rather other factors such as fuel level may be more important.

A plausible explanation for the results relative to level of decision agreement is that when passengers are onboard, pilots are less willing to make risky decisions compared to when they have cargo payload. Pilots may have taken more care with their decisions when passengers were onboard due to the weight of a negative outcome (loss of life). However, it is important to note, that the difference in rating was not large (rating of point .30 out of 5).

Research Question 2: What is the effect of framing on the riskiness of weather-related decision-making?

Three measures were used to answer this research question. The first measure was the categorical decision outcome, and it was examined using the Friedman test. The Friedman test indicated a significant difference between the three different types of frames on the dependent variable. The scenarios with gain-framed decision options had more instances of returning to the departure site (risk-aversion) compared to loss- and no-frame scenarios. One plausible explanation for this is relative to Kahneman and Tversky's (1979) framing effects. In the context of the current study, framing decision options as a gain led to risk-aversion (returning to the departure site), whereas, framing decision options as a loss led to more risk-seeking (continuing to the destination site). However, the no-frame had higher risk-seeking than loss-framed decision options. The finding that pilots were risk-seeking in scenarios void of frame is consistent with previous literature. Goh and Wiegmann (2001) found that pilots made more risk-seeking decisions (continued to the destination) in scenarios void of frame. This may be due to pilots inherently having a more risk-seeking nature that has previously been identified (Ebrahim et al., 2021). The lower number of risk-seeking decisions for loss-framed decision options when compared to the no frame condition may have been due to anchoring from the gain-frame decision options always being presented prior to loss frames. Potentially, participants were still sensitive to the previous frames, and it led to more risk-aversion than it would have if gain frames were not presented prior to loss frames.

The second analyses used to examine whether framing had an effect on the riskiness of weather-related decision-making was the repeated measures MANOVA on decision time and the continuous decision outcome variable. The effects of frame on decision time and continuous decision outcome were significant at the multivariate and univariate levels. Pairwise comparisons revealed that the difference was only significant between gain frame and no-frame condition but neither were significantly different from the loss frame condition. When examining the differences in their continuous decision outcome variable, on average, when they were presented with the no-framed and loss-framed conditions they rated their decision more consistently with “Neither Agree to Divert or Continue.” However, on average, when participants were presented with the gain-frame condition they rated their decision outcomes, as more risk-averse.

A plausible explanation, when examining decision time, is that the difference found between gain-framed decision options and no-frame decision options may be due to a flaw in the study design as the decision options for frame consisted of only eight words (Continue to Destination site or Return to Departure site). However, decision options for gain frame were much longer consisting of an average of 90 words. Therefore, the difference found may be due to the amount of time the individual spent reading the decision options rather than decision-making time. When comparing the time it took to read grain-framed decision options compared to loss-framed decision options that were on average 83 words, the difference was not significant. Research supports that on average individuals read around four words per second (Brysbaert, 2019). No significant difference between decision times for no frame and loss frame were found although loss frame had an average of 83 words. This is interesting due to the similarities in decision time difference between the loss versus gain frame and loss versus no frame. One plausible explanation is that in general, decision time may not be a good indicator of risk in an aviation context. That is, it may be so engrained in pilots that their decision time must be short due to the high stakes environment that times may not be a good indicator. Further, loss-framed information and no framed information may yield similar mentalities leading them to yield more equivalent results. The reader should note that these results should be interpreted with caution given the confounding variable of decision option length and associated reading time.

With respect to the continuous decision outcome variable, one plausible explanation for the results is that participants were less willing to make a risky decision when decision options were framed as gains compared to losses. The risk-averse decisions for gains may have led to higher levels of agreement due to making more certain safe decisions. Framing theory posits that when information is framed in terms of gains, people are more likely to make decisions that produce certainty (Wickens et al., 2017). Returning to the departure site is the only certain option compared to continuing to a destination where the conditions are uncertain therefore participants may have been more likely to agree with their decision.

Research Question 3: What is the interaction between payload type and framing for riskiness of weather-related decision-making?

The repeated measures MANOVA was used to examine whether the interaction between payload type and framing had an effect on the riskiness of weather-related decision-making using decision time and the continuous decision outcome variable. The interaction between frame and payload for decision time was not significant, $F(1.55, 78.97) = 1.8$, $p = .18$. The interaction between frame and payload for the continuous decision outcome variable was not significant, $F(2, 102) = .086$, $p = .92$.

One plausible explanation is that there did not seem to be a large effect of payload, in general. It also suggests that framing does not have a differential effect on decisions based on payload type. That is, regardless of whether there are passengers or cargo onboard, the framing effects were consistent.

Another plausible explanation is related to the sample size, as the power for the interaction was .192. Given that theory suggests there would be a significant interaction, then it is likely that a the lack of significance is due to a type 2 error.

Implications

The following section presents the implications relative to prospect theory and prior research presented in Chapter 2.

Implications Relative to Theory

The theory the current study was grounded in was Kahneman and Tversky's (1979) prospect theory. Prospect theory posits that individuals are typically more risk-averse for gains (i.e., unwilling to partake in risk to obtain gain) and risk-seeking for losses (i.e., willing to take a risk to avoid a loss). This is proposed to be due to the perceived consequences of a loss being felt more deeply (weighted more severely) than the perceived consequences of gain (Kahneman, 2011; Wickens et al., 2017). The slope of the value function associated with prospect theory (see Figure 2.1) also decreases with movement away from the origin. This indicates diminishing perceived utility for both gains and losses. Relative to the theory it was hypothesized that an equivalent objective loss (late cargo vs. late passengers) will have a higher negative utility for a UAM flight when the payload was a passenger compared to when it was cargo due to greater perceived value of human life. Therefore, it was expected that participants would be more likely to continue to the destination site with passengers compared to cargo as payload. Further, relative to theory, it was hypothesized that gain-framed decision outcomes would lead to risk-aversion and loss-framed decision outcomes would lead to risk-seeking.

In the current study some of the findings supported prospect theory. When examining the findings relative to utility, the findings did not support prospect theory, as higher utility (i.e., passengers) did not lead to more risk-seeking. Rather, although not significant, flights with cargo onboard had higher risk-seeking. According to theory, this may be due to the weight of hurt passengers being so high that it was overestimated (Wickens et al., 2017; p. 267). Consistent with prospect theory, framing effects occurred. Gain-framed decision options led to risk-aversion or returning to the departure site. Additionally, loss-framed decision options led to risk-seeking or continuing to the destination site.

Implications Relative to Past Research

The results from the current study are in line with some of the previous research. When examining the results relative to utility in the current study, they are not in line with most of the extant research. Most studies examining utility manipulation on decision-making found that higher utility led to higher risk-seeking (de Souza et al., 2020; Diederich et al., 2020; Fagley & Miller, 1997). That is, as utility increased, so too did risk-seeking behavior, which is supported by the finding that framing effects are stronger for lower utility decision outcomes compared to those with high utility in gain frames. A potential reason for the current finding may be due to past research studies using the Asian disease problem in which the loss and gains are relative to children's lives compared to an inanimate object such as a home, unlike the current study which did not specify the age of the passengers. In instances using children lives like the Asian disease problem, the differences in utility may be more pronounced. For example, Zhou et al., (2021) examined the impact of framing using scenarios of varying utility. Four scenarios were used: (1) the fish kidney disease in which fish species were at risk, (2) water contamination in which children's lives were at risk, (3) endangered forest in which acres of an endangered forest could be lost, and (4) genetically engineered crops in which crops could be lost. Findings were consistent with prospect theory in that risk-seeking was highest in loss scenarios using the water contamination scenario potentially due to the fact that the researchers included that it would result in loss of children's lives rather than just human lives. However, some studies have found risk-seeking to be lower with higher utility outcomes. For example in Zhou et al., the gain-framed scenario the fish lives yielded less risk-aversion than children's lives. A description of scenarios is available in Chapter 2.

The results related to frame support findings across multiple domains that gain-framed information leads to risk-aversion, whereas loss-framed information leads to risk-seeking (Abdellaoui et al., 2013; de Souza et al., 2020; Druckman, 2001; Guo et al., 2017; O'Hare & Smitheram, 1995; Ronnlund et al., 2005; Roszkowski & Snelbecker, 1990). The current study found no interaction between framing and utility unlike previous research. Several past research studies found an interaction between framing and utility (Jou et al., 1996; Roszkowski & Snelbecker, 1990; Souza et al., 2020; Zhou et al., 2021). Cited research indicated that in most cases, framing effects are stronger for lower utility in gain-framed scenarios and stronger for higher utility in the loss-framed scenarios (de Souza et al., 2020; Jou et al., 1996; Roszkowski & Snelbecker, 1990; Zhou et al., 2020). This is likely due to the fact that when decision options are presented as losses, people are willing to take a larger risk in an attempt to avoid a loss altogether, rather than be risk-averse and ensure that they experience a loss. Whereas, for gain-framed scenarios individuals are not going to take a risk for decision outcomes of lower utility (i.e., where they have less to gain). For example, if there is cargo onboard that is not time sensitive, a pilot is going to be more likely to make the decision to bring the cargo back to the departure site to ensure that the cargo is safe. Whereas if the cargo is time sensitive, although bringing the cargo back may be the safest option, they may continue to the destination to ensure that the cargo arrives on time.

Research that can be directly compared to the current study is extremely limited. Only two aviation studies have examined prospect theory using framing in the traditional manner in which participants were presented with either gain- or loss-framed scenario information and asked to make a decision (O'Hare & Smitheram, 1995; Walmsey & Gilbey, 2020). The findings of the current study are somewhat in line with Walmsey and Gilbey (2020). Walmsey and Gilbey presented participants with 10 scenarios, half of which were gain framed and the other were loss framed. Eight of the scenarios were weather related and the other two were ATC related. They attempted to manipulate utility using different reference points such as how much money or time the participant had to start. When examining their results related to utility, Walmsey and Gilbey found that scenarios with higher utility led to more risk-aversion, inconsistent with prospect theory. The current study's findings are in line with Walmsey and Gilbey if the authors are willing to accept the adjusted alpha level of .075, as the MANOVA revealed that participants responses for the continuous decision outcome variable were more risk-averse for the passenger payloads compared to cargo. Additionally, the same was found when examining the descriptive statistics related to the number of risk-seeking decisions (i.e., continuing to the destination) versus risk-averse decisions (i.e., returning to the departure site) by each payload condition: more risky weather-related decisions were made with cargo (n = 87) compared to passengers (n = 72). A plausible reasoning for this result is that pilots may be more willing to make a risk-averse decision ensuring a loss (i.e., decide to return ensuring that the payload is late) rather than a risk-seeking decision where the outcome could be more catastrophic, in an attempt to avoid a loss (i.e., continuing to the destination potentially leading to an accident). Some research has supported that in certain situations individuals wish to minimize their maximum loss when the option has a catastrophic negative outcome (Wickens et al., 2017, p. 267). In the context of the current study this would mean that participants would feel that an accident with passengers onboard the aircraft would be more catastrophic and make a decision consistent with risk-aversion in loss frames rather than risk-seeking. Walmsey and Gilbey found mixed results related to framing, as framing effects were consistently found for gain-framed scenarios, that is, participants made risk-averse decisions more frequently, but not all loss-framed scenarios led to higher risk-seeking decisions. The current study is not entirely in line with these findings as participants made more risk-averse decisions when decision options were framed as gains and more risk-seeking decisions when decision options were framed as losses. A plausible reason for the results of the current study not being consistent with Walmsey and Gilbey is that the framed information used in both studies was different. The current study did not use probabilities in the framed information, nor did it use monetary losses or gains.

The findings of the current study are in line with O'Hare and Smitheram (1995) who examined the application of prospect theory to pilots' decisions about whether to continue into deteriorating weather. In their study, participants were asked to complete a simulated cross-country flight wherein at approximately three fourths of the way into the flight, they were presented with marginal weather and asked whether they wanted to continue or divert, with information being presented either in a gain or loss format. The current study findings were consistent with O'Hare and Smitheram who found that gain-framed decision options led to risk-aversion and loss-framed decision options led to risk-seeking. Further, O'Hare and Smitheram examined whether there was an effect of frame type on decision times and found no significant difference in decision times between frame. The current study had similar results as no significant difference was found in the decision times between gain-framed scenarios and loss-framed scenarios.

The current study builds on the O'Hare and Smitheram (1995) and Walmsey and Gilbey (2020) studies in a few key ways. First, the current study was conducted in a remotely-piloted UAM context. Both of the prior studies were conducted in the context of a manned flight in which participants were asked to imagine they were on-board the aircraft. Therefore, the current study is more representative for future operations in which there will not be a pilot onboard the aircraft. Second, the current study captured participant's natural frame. Although Walmsey and Gilbey attempted to capture participants' natural frames, they did so post-study, wherein previous research has pointed to the stickiness of frames (Ledgerwood & Boydstun, 2014). The current study included two scenarios free of framed decision options at the beginning of the study to avoid anchoring.

Implications for Aviation Practice

The implications for the aviation and UAM industries are important to consider, especially due to the emergent nature of the UAM industry. The current study found no significant difference in decision-making by payload at the preset alpha of .05, however it did at an alpha of .075. Potentially, pilots merely knowing whether their payload is comprised of humans versus cargo may not affect their decision-making. However, presenting pilots with more granular information about their payload such as passenger names, whether they are adults or children, and number of passengers could impact the riskiness of their decision-making. Further, there is a potential that pilots may simply weigh the utility of actions or payloads differently when not physically located onboard themselves. Past research utilizing drone operators has supported that the distance between operators and the location where their decisions take place creates, “emotional distance, ethical detachment, and psychological dissociation from the consequences of those actions”. (Asaro, 2013). Further examination is needed in this area. Practitioners and OEMs should examine how different levels of information about the payload and separation between pilots and their payload impacts their decision-making. As the UAM field continues to mature, research is needed to understand pilot decision-making to create policies that facilitate low risk decisions.

When examining the results relative to framing and implications, the current study’s findings yielded support for framing impacting decision-making. Specifically, presenting pilots with gain-framed decision options led to more risk-averse decisions whereas presenting pilots with loss-framing led to more risk-seeking decisions in the face of marginal weather. One possible implication from this finding of the current study is that framing could potentially be a useful tool for aircraft OEMs. Finding a way to leverage gain framing in displays could impact pilots' decision outcomes. Further, an interesting finding relative to decision-making was that when pilots were not presented with any frame, their decisions were risk-seeking. As aforementioned in the previous chapter, this could be a result of pilots inherently having a more risk-seeking nature (Ebrahim et al., 2021). Policy makers should keep in mind pilots' natural risk-taking tendencies as well as how framing may affect these tendencies when creating policies and training.

Generalizability, Limitations and Delimitations

Generalizability

This section discusses the external validity or extent to which the current study's results can be applied to the populations and settings. With respect to population validity, that is the extent to which the results can extend beyond the population from which the sample emerged, the parent population is presented in the demographics table in Chapter 3 of the current work (see Table 3.1). When examining the study's ecological validity or the ability of the experimental environment to apply to different settings, conditions or circumstances, the reader must take several constraints into consideration. First, the reader must take into account that the study was not a simulated task in which the participant controlled the aircraft, but a survey format in which the participant watched a flight scenario unfold and made a decision. The simulated task scenario was conducted in a specific location, New York city which may not be representative of UAM operations in other cities. The use of simulated weather and additionally the weather in the scenario does not span all weather presentations. All of these circumstances impact the ability for the findings to apply to true future UAM operations. These and many other features, constraints, and limitations of the study have been presented throughout the current work to allow readers to make an informed decision. The results of the study are most applicable to a highly automated remote UAM operation wherein the pilot or operator is performing more of a visual task and only intervening when necessary.

Study Limitations and Delimitations

The current study experienced many limitations and delimitations. The limitations and delimitations from Chapter 1 have been replicated in this section to set the stage for the next section, which presents recommendations for research and practice relative to the study's limitations and delimitations.

Limitations. Limitations are conditions, events, and circumstances that are beyond the control of the researcher and therefore can affect the generalizability of the study and findings. Limitations for the current study included

1. Representativeness of the Sample. The sample consisted of Florida Tech students with flight experience or UAS experience, helicopter pilots who were part of HAI due to their knowledge of airspace and experience flying/operating smaller aircraft, pilots who were members of the National Association of Flight Instructors (NAFI), and pilots who were on social media. I did not have control over the experience and prior training of my sample nor what experience is required for future UAM operations. Given that the requirements for future UAM pilots do not currently exist, there may be different training requirements in the future yielding additional differences between the current sample and UAM pilots, limiting the generalizability of the current study.

2. Representativeness of the Selected Vehicle. I did not have control over the vehicles that will be certified for future UAM operations. Therefore, the simulated vehicle used in the study may not be representative of what UAM vehicles are ultimately used, and therefore limit the generalizability of the study's findings. The vehicle selected for the current study was selected based on UAM literature that has emerged thus far and communication with current experts in the field. Therefore, a study which uses a vehicle which is representative of the final vehicle may yield differing results from the current study.

3. Representativeness of Scenarios. As was previously stated, the current study was based on the UAM literature that has emerged thus far and communication with current experts in the field. However, the field is not extant and may not be for the foreseeable future, therefore changes in factors relative to the flight, and departure/destination sites have the potential to change after the study. Therefore, locations of the destination and departures may not be representative of future flights and therefore limited the generalizability of the study's findings. As such, studies that use scenarios once they are finalized may yield different results from the current study.

4. Integrity of Participants' Responses. The measures utilized in the study were self-report and participants may not have been truthful or forthcoming with all of their responses. As such, similar studies that are not self-report and require participants to respond to all questions may yield different results.

Delimitations. Delimitations include constraints on the study that I as the researcher, imposed on myself to improve the feasibility of the current study, but that may have impacted the interpretations and generalizability. Delimitations of the current study include:

1. Sampling Strategy. The current study utilized both convenience sampling and snowball sampling. With respect to convenience sampling, any participant from the accessible population that was willing to participate was included. Additionally, any individual identified by another participant as matching the requirements for participation was allowed to participate. Both sampling strategies were used in hopes of maximizing the amount of study participants. However, this sampling method may have resulted in a non-representative sample. If a similar study were conducted using a different sampling strategy, the study might yield different results.

2. Participant Inclusion. The current study removed any participants who did not make a decision for all six scenarios because MANOVAs are not robust against missing data and mean computation is not appropriate when large amounts of data are missing. However, this may have led to a biased sample. If a similar study were conducted with more data points none of which were excluded, the results could be different from the current study.

3. Study Design. The current study used a repeated measures design to examine how different payload types affected the riskiness of weather-related decision-making when most other variables were held constant. The use of a within group repeated measures design may, however, have primed participants in their subsequent scenarios when they realized the pattern of the scenarios, wherein they would be making a decision to continue or return for similar weather. A similar study using another design such as a between-subjects design, that does not provide the participant with more than one framed scenario or payload might yield different results.

4. The Simulated UAM Aircraft. The UAM aircraft chosen for the current study was selected due to its inexpensive cost and the fact that it was representative of models vying for certification. However, there are other simulated vehicles available for purchase, none of which are considered to be more representative of future vehicles than others, as no vehicle has been certified and verified for mass production. However, the interface chosen for the current study may not be representative of the information used in future UAM aircraft as the UAM space matures. A study which employs a different vehicle might yield different results than the current study.

5. Representativeness of Scenario Challenges. The weather selected in the current study's scenarios did not span the full range of weather challenges UAM pilots may experience. Weather presentation was also done using a table format to reduce the amount of reading time for participants. Therefore, studies which use other weather challenges, such as, icing conditions or present weather in formats pilots may be more familiar with, such as, on a display might yield differing results compared to the current study.

6. Representativeness of the Task Load. The study was presented as video recordings via Qualtrics survey software due to testbed limitations presented in Chapter 3. Participants were unable to control the aircraft and instead watched a simulated flight. Although the simulated software allowed for the replication of a high-risk scenario at an appropriate air space a simulator cannot imitate the true workload, time demands, and environmental stressors that a live UAM flight would impart. Further the lack of controls or ability for the participants to actively fly the vehicle cannot imitate the true demands of operating an eVTOL. The use of the survey software led to an inability to control the location where the survey study was completed and may have yielded location effects. Therefore, future studies utilizing a vehicle that can be controlled and in one location might yield differing responses. Additionally, future UAM pilots in a real-world UAM flights may not yield the same level of responses as they do in the current study, limiting the generalizability of the study.

7. Decision-Making Measures. The current study used two decision-making outcome measures that were selected based on previous studies examining prospect theory. The first being a dichotomous measure with the option to continue to the destination site or return to the departure site. The second a continuous measure, that included a rating of the level of agreement to continue or return to the departure site. These measures may not cover all aspects of decision-making. Further, the continuous decision outcome measure did not use precise wording. Studies that use a differing continuous scale such as confidence scale might yield different results.

8. Time measure. The current study measured the decision time for all six scenarios. However, the length of the decision options might have resulted in a difference in decision times, resulting in our inability to accurately interpret effects of framing and payload on decision time.

9. Representativeness of Decision Options. The current study utilized information from the literature in the UAM field and experts to create decision options that might not represent the full array of options or information typically available to pilots. For example, in real-life, a pilot may decide not to continue to the destination location or return to the departure site, but rather decide to divert to an alternate site or change altitudes, alternatives that were not included in the current study. Therefore, studies that include the option to divert or change altitude may yield differing results from the current study. A study that uses different or additional information within the decision options could result in other decision outcomes for the pilot.

10. Counterbalancing. The current study utilized counterbalancing to account for the anchoring which can be experienced by payload. Therefore, studies which do not use counterbalancing and employ other methods such as randomization might yield different results than the current study.

11. Data Collection Issues. The current study was unable to collect data pertaining to whether participants actually clicked in and viewed the video on Qualtrics. Therefore, studies that include a feature that allows the researcher to know whether the participant watched the simulated video might yield different results than the current study.

Recommendations for Research and Practice

Recommendations for Research Relative to Study Limitations

The recommendations for future research relative to study limitations are presented below.

1. The current study utilized pilots with varying flight experience and backgrounds. Future studies should attempt to obtain a sample representative of the experience which will be required of UAM pilots once finalized.
2. The current study utilized convenience sampling to collect more data and is not representative of all individuals with flight experience. Future

studies should attempt to collect a larger and more diverse sample utilizing random sampling strategies rather than convenience sampling.

3. The current study utilized a simulated eVTOL aircraft that although representative of some of the eVTOLs in the market, is not representative of all eVTOL aircraft and potentially the aircraft for future UAM operations. Future studies should utilize other eVTOLs such as a tilt-wing aircraft.
4. The current study created weather scenarios based on recommendations from subject matter experts and the limited literature available related to UAM operations and weather. The current study presented participants with information related to cloud level, visibility, precipitation, and wind. Future studies should expand and vary the weather presented to the pilots as more information evolves related to the type of weather pilots will be able to operate within.

Recommendations for Research Relative to Study Delimitations

1. The current study utilized convenience and snowball sampling leading to a sample that may not be representative. Future research should utilize an alternative more robust sampling strategy such as purposive sampling.

2. The current study removed participants who did not make a decision to continue or divert for all six scenarios, which may have led to a biased sample. Future research should attempt to use methods which will encourage participants to answer all questions such as forced-response features on surveys.
3. The current study used a within groups repeated measures MANOVA to protect against individual differences, however, this may have led to anchoring. Future research should utilize an alternative design which will not yield anchoring such as between subjects experimental design, wherein each participant is only presented with one frame to avoid any anchoring and priming.
4. The current study utilized a simulated aircraft based on the literature and available low cost simulated vehicles. However, there are many different types of vehciles, therefore future studies should utilize other vehicles that may be more representative of UAM.
5. The current study presented pilots with weather information based on feedback from experts in the field and used a table format as well as the software to present weather to pilots. However, this does not span the full weather challenges pilots may face. Future studies should attempt to

provide additional weather such as snow. Further, present the framed weather in a format that is more representative of how UAM pilots would receive that information, whether it be controller pilot data link communications (i.e., text messages) or via some sort of traffic management service.

6. Due to limitations related to weather presentation in the simulation, the current study was performed as a vignette-based survey study as opposed to a simulation study. Therefore, the lack of task load, such as, flying the aircraft during the scenario might have impacted level of immersion, representativeness of the study. Future studies should perform a simulation study where participants must fly the aircraft and/or performing additional side tasks representative of those which future UAM pilots will perform, will have on riskiness of weather-related decision-making.
7. The current study used two decision-making measures to measure the riskiness of weather-related decision-making based on the literature: a categorical-decision outcome variable and a continuous decision outcome measure. Future studies should attempt to use other measures such as a decision confidence measure.

8. The current study was unable to examine decision time due to an error made in the length of decision options between frames. Future research should ensure that the amount of information presented per decision option is equivalent and therefore, differences that emerge are due to decision making time rather than the time it takes to read decision options.
9. The current study utilized information from the literature in the UAM field and experts to create decision options that examined two types of payloads: passengers and cargo and did not represent the full array of information or options that pilots may have available. Future studies should expand on the payload (i.e., amount of cargo, type of cargo, or age of passengers). Future studies should examine how varying types of payloads impact the riskiness of weather-related decision-making. For example, instead of amazon packages, they could consider using a cooler containing a heart for a transplant, and varying amounts of passengers and the information about the passengers presented to the participants. Additionally, future studies should include additional decision options that may be available to pilots, such as, deciding to divert to an alternate site or change altitudes.

10. The current study used counterbalancing to account for the effects of payload but this may have led to anchoring. Future studies should present participants with one type of payload, that is use a between subjects design to avoid anchoring.
11. The current study utilized Qualtrics software to present participants with a recorded simulated flight presented on YouTube, due to an inability to properly control the weather presented to pilots. Although YouTube was beneficial in providing participants with high video quality, it made it impossible to ensure that all participants truly watched the simulated video. Future studies should ensure that participants cannot exit the simulated flight unless they want to exit the study.

Recommendations for Future Research Relative to Implications

The following section discusses recommendations for future research and practice based on the implications discussed within this chapter.

1. The current study's findings are not consistent with payload having a significant impact on the riskiness of weather-related decision-making. As discussed in the implications section, this could be due to the distance of the decision maker from their payload leading participants to weigh their payload equivalently. Therefore, presenting pilots more

granular information on their payload such as passenger names and number of passengers should be examined to see how it impacts their decision-making. Emerging press related to eVTOLs has introduced models and concepts such as the Bell Nexus, which are intended to be used as air taxis, and provide operators with passenger names and images. Practitioners and OEMs should examine how the amount of information on payload that is presented to pilots impacts their decision-making.

2. The current study's findings were not consistent with prospect theory in that cargo had higher risk-seeking than payload. Future research should look at replicating the study with an additional measure that examines the assigned utility value to compare the values.
3. The current study found that framing decision options as gains led to risk-averse decisions whereas framing decision options as losses led to risk-seeking decisions. The implication is that framing can impact the riskiness of weather-related decision-making. Future research should examine what information in particular being gain framed is the most impactful to their final decisions to return to the departure site. This will provide a better understanding of what information should be framed to

pilots. For example, pilots may yield stronger framing effects for gain-framed information related to happy passengers versus the rewards of an on-time arrival. Future research should also examine how framing can be incorporated into aircraft to impact weather-related decision-making. For example, studies could utilize short, framed alerts on top of weather displays, such as the multi-function display, with a line of text saying "30% chance of on time arrival and 70% chance of safe diversion given conditions" when the weather is deteriorating.

4. The current study's findings with respect to decision times for gain and loss frames is consistent with previous research. Future studies should replicate the study and ensure that the framed information is equivalent across frame conditions.
5. The current study did not yield significant results for the interaction between framing and utility. Given the results of the post hoc power analysis, this may be due to the small sample size used in the study.
6. The current study found that pilots not only made more risk-seeking weather-related decisions when loss framing was used but also no-frame, therefore pilots may just naturally be more risk-seeking. Researchers should further examine pilot's natural risk-taking

tendencies. Future research should examine whether framing could be used during weather-related training to promote risk-aversion. Pilots should be educated on their natural propensity for risk. Providing pilots with tools to identify risk-seeking behavior in the moment or training to influence their reference points could potentially impact their risk-seeking behaviors (Kahneman & Tversky, 1979; Page et al., 2014).

Recommendations for Aviation Practice

The following section discusses recommendations for aviation practitioners.

1. The Federal Aviation Administration should work to finalize the certification required for UAM pilots. This will make it possible for practicioners to understand aircraft learnability for different rated pilots.
2. Those in the UAM space namely OEMs should determine the best way to present weather information and think about adding gain framing to displays.
3. Weather training for pilots should be amended to ensure that it is appropriate for remote UAM pilots.
4. The impact of weather phenomena on eVTOLs should be examined and how it may impact passenger adoption.

5. Practitioners should discern the most appropriate method of presenting mechanical wind turbulence on weather displays as it will be a large challenge for future UAM pilots.
6. Pilots should be made aware of their biases to different payload types to help them in making appropriate decisions regardless of what or whom is onboard.
7. Training should be created on to how to self-identify risk-seeking behaviors and how to change them should be incorporated.

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Appendix A

FLORIDA TECH

RESEARCH INVOLVING HUMAN PARTICIPANTS
EXPEDITED/FULL APPLICATION

This information listed below should be submitted to Florida Tech's IRB if the proposed research has more than minimal risk (none of the exempt conditions apply) or if the research utilizes a special population (children, prisoners, institutionalized individuals, etc.). Please consult the IRB website for detailed information, or contact the IRB Chairperson.
floridatech.edu/research/compliance--regulations/institutional-review-board

Submit via email to FIT_IRB@fit.edu.

IRB Contact Information:
Dr. Jignya Patel
IRB Chairperson
FIT_IRB@fit.edu
321-674-7391

PART 1: GENERAL INFORMATION

Title of project Examining the Effects of Payload Type and Framing on the Riskiness of Weather-Relate

Date of submission March 25, 2022

Expected project start date April 7, 2022 Expected project duration 1 year

Principal investigator Maria Chaparro Osman

Title Graduate Student

Academic unit College of Aeronautics

Phone 7725329236 Email mchaparro2016@my.fit.edu

List all co-investigator(s). Please include name, title, academic unit/affiliation and email.

Dr. Meredith Carroll, Professor, COA, mcarroll@fit.edu
Maureen Namukasa, graduate student, COA, mnamukasa2020@my.fit.edu

PART 2: PROJECT SPONSORSHIP INFORMATION

If any part of this study will be funded by an external funding source (current or planned), you must note the funding source and award/solicitation number below:

This project will not be funded by any external sources.

PART 3: RESEARCH DESCRIPTION

1. In lay terms, please describe the GENERAL PURPOSE of the study and how human subjects will be involved. List the SPECIFIC AIMS and RESEARCH QUESTIONS or HYPOTHESES. Avoid the use of jargon when describing the purpose of the study.

The purpose of the current study is first to examine the effect of payload type on the riskiness of weather-related decision making in a simulated UAM environment. Second, the proposed study will examine whether framing information using prospect theory influences the riskiness of weather-related decision making in a simulated UAM environment.
RQ1. What is the effect of payload type on the riskiness of weather-related decision making?
RQ2. What is the effect of framing on the riskiness of weather-related decision making?

2. Outline the INCLUSION CRITERIA for subjects, explaining the rationale for the involvement of any special groups, including children, prisoners, pregnant women or subjects with cognitive impairments. Describe the characteristics of the targeted subjects, including gender, age ranges, ethnic background and health/treatment status. If women or minorities are excluded, provide written justification. Give the number of subjects you anticipate including from each targeted group listed above.

No vulnerable groups will be used in the study, Participants must be at least 18 yrs. of age with some level of flight experience that is either experience with a UAS, plane, or helicopter.

3. Describe sources for potential participants, how subjects will be RECRUITED or the sampling procedures. Attach recruitment advertisement(s), if applicable.

The sampling strategy used to obtain students and pilots from the accessible population will be convenience sampling and snowball sampling. To obtain all participants, a flier asking for participants with flight experience for either remotely or on-board piloted aircraft with at least 18 years of age will be disseminated online through Florida Tech's list service, instructor, student and aeronautical colleague emails, social media and students will be recruited through FIT classes wherein extra credit will be made available for participating in the study. Any student 18 years of age or older with flight experience or who are pursuing a UAS pilot's license may participate. The same flier will be distributed to those who are part of the Helicopter Association International (HAI) for distribution to their members as well as around the center of aeronautics and innovation and the flight line to obtain non-student pilots with rotary or fixed wing experience. Those who participate will be told that they may share the flier with other pilots who they believe may be interested.

4. Describe any COMPENSATION the subjects will receive, including course credit. If monetary compensation is offered, indicate how much the subjects will be paid and describe the terms of payment.

All participants will be entered to win one of three $25 Amazon gift cards and an aviation goody basket. Instructors at the College of Aeronautics (COA) will be asked to provide extra credit to students in their classes who complete the study, therefore those who sign up through their classes may receive extra credit. Alternative extra credit may be offered to those who do not wish to participate.

5. Explain how CONFIDENTIALITY and privacy of participant data (and anonymity if appropriate) will be maintained. If the research study involves collection of images or audio recordings of subjects, explain how the material will be used, who will see the images or hear the recordings and in what setting (refer to the audio/video recording policy).

No images or audio recordings of subjects will be used for the study. Informed consents and data collected will be kept digitally on Qualtrics and participants will be assigned a unique number so that their information is not tied to their name. Only researchers conducting the study will have access to participant data.

6. Describe the study design/research/measurement PROCEDURE (e.g., control and experimental groups, etc.). Indicate whether or not the subjects will be randomized for this study. Discuss how you will conduct your study and what measurement instruments you are using. List the specific steps of your research protocol. Explain scientific jargon. Attach a copy of any questionnaires, measurement instruments, interview protocols or a description of topics or an approximate script that will be used. If not available at this time, explain. Please describe your study in enough detail so the IRB can identify what you are doing and why.

The study will be an experimental design, specifically a within-subjects repeated measures as all participants will be watching a recording of 6 (one minute) simulated flight scenarios within a qualtrics survey. Participants will not be randomized as all participants will receive all scenarios. Counterbalancing will be used for aspects of the scenarios specifically whether they are transporting cargo or passengers and this will be done via qualtrics. The first part of the survey will ensure that they meet the inclusion criteria of being 18 years of age or older and having flight experience. If they have both they will then be able to access the informed consent to participate in the study. After signing the informed consent they will be given a pre-survey in which they will be asked to report: age, biological sex at birth, ethnicity, race, experience (UAM class, video game, UAS, weather experience, and type of flight), video game frequency, and flight hours. Participants will then view six simulated flights. At the end of each scenario, participants will be asked whether they would continue or divert a flight based on the weather. Their response and the time it takes to make this decision will be collected. After each scenario, participants will be asked why they made the decision to continue or divert, their level of agreement with the decision to continue or divert, rate workload using the NASA-TLX, and a free-response question asking them to elaborate on their reasons via the qualtrics survey. After all six scenarios, the participants will fill out a post-survey which will collect risk using the risk propensity scale, and ask them to rate the level of risk associated with weather, as well as their comfort flying in that weather. All pre-surveys and post-surveys are attached to this IRB

7. If the study will use deception, describe the nature of the deception, discuss why deception is necessary and fully indicate how participants will be debriefed. Deceptive techniques must be justified by the study's prospective scientific, educational or applied value, and the investigator should explore equally effective alternative procedures that do not use deception. A debrief form/process must be discussed here.

No deception will be used in the current study.

8. Describe all SITES where this research will take place and attach documentation of permission from the appropriate source if the study involves subjects from places other than common public spaces.

The research will take place wherever the individual is using their computer or mobile device to access the survey.

9. Describe any POTENTIAL RISKS (physical, psychological, social, legal or other) and the steps that will be taken to minimize risk. Where appropriate, discuss provisions for ensuring necessary medical or professional intervention in the event of adverse effects to the subjects. Also, where appropriate, describe the provisions for monitoring the data collected to ensure the safety of subjects. Research involving children must carefully assess risks and describe the safeguards in place to minimize these risks.

The risks involved in the current study are no more than that of using a desktop flight simulator.

10. Discuss the importance of the knowledge that will result from your study and what benefits will accrue to your subjects (if any). Discuss why the risks to subjects are reasonable in relation to the anticipated BENEFITS to subjects.

Participants will be able to watch a simulated eVTOL flight and share their experience related to decision making and risk to help inform decision making in an Urban Air Mobility context. Results could help inform the design of future UAM pilot interfaces and training.

11. CONSENT. Informed consent can be in either written or oral format. If you request waiver of informed consent, documentation of informed consent or of written informed consent, please state your justifications. Attach consent form if applicable. If an oral consent is planned, attach a copy of the text of the statement. If the study will be conducted with minors, provide an assent script. If assent is deemed unnecessary or inappropriate, you must discuss why. The consent form should contain all eight elements listed in Part 4. Researchers are strongly encouraged to use the formal headers found in Part 4, Item 3 to structure the consent document.

Informed consent is attached.

Appendix B

Informed Consent

Please read this consent document carefully before you decide to participate in this study.

Study Title: Examining the Effects of Payload Type and Framing on the Riskiness of Weather-Related Decision Making in a Simulated Urban Air Mobility (UAM) Environment

Purpose of the Study: The purpose of the study is to understand how decision making is impacted in an urban air mobility environment.

Procedures: If you choose to participate you will view six recorded simulator flights and answer questions related to the flights.

Potential Risks of Participating: There are minimal risks in participating in this study, risks are no more than filling out a survey on a personal computer or laptop.

Potential Benefits of Participating: There are no immediate benefits for participating, however, the results of the study will help inform decision making in an Urban Air Mobility environment.

Compensation: Any students who complete the study while enrolled in a course with an instructor offering extra credit for participation may receive extra credit, furthermore, all participants will be entered into a raffle where they may win a $25 Amazon gift card or aviation gift basket.

Confidentiality: If you are receiving extra credit for your participation in the study, your name and email will be collected and submitted to your instructor. If you are not receiving extra credit, then personally identifying information will not be collected during the study. All demographic information used in any report will be reported in aggregate.

Voluntary Participation: Your participation in this study is completely voluntary. There is no penalty for not participating. You may also refuse to answer any of the questions we ask you. You have the right to withdraw from the study at any time without consequence. Any information you provided prior to withdrawing will be destroyed.

Whom to contact if you have questions about the study:
Dr. Meredith Carroll
(321) 674 – 8374
mcarroll@fit.edu

Whom to contact about your rights as a research participant in the study:
Dr. Jignya Patel
IRB Chairperson
FIT_IRB@fit.edu
321-674-7347

Agreement:

I have read the procedure described above. By clicking I agree to participate, I am voluntarily agreeing to participate in the survey.

○ I agree to participate ○ I do not agree to participate

End of Survey If Consent = I do not agree to participate

Appendix C

Study Introduction

Thank you for completing the informed consent. The purpose of the study is to understand how decision making is impacted in an urban air mobility environment. Urban Air Mobility is an emerging aviation transportation system that will use highly automated electric vertical takeoff and landing (eVTOL) aircraft to transport passengers or cargo at lower altitudes (e.g., 500 – 5,000 feet) within urban and suburban areas. There are a few key challenges and benefits of these aircraft, for example:

eVTOL aircraft are less tolerant of weather than most aircraft due to their smaller size. Weather approaching 20 knot winds, heavy rain, and non-VFR visibility can negatively impact the safety of eVTOL operations by making safe navigation and a safe landing much more difficult. FAA VFR minimums for aircraft more than 1200 feet above the surface in weather clear of clouds is ½ statute mile of visibility, while operations occurring 500 feet below the clouds must have 1 statute mile of visibility. Furthermore, when fog is present visibility should be no less than 3 statute miles. Although these aircraft have limitations, eVTOL aircraft will be a more efficient travel alternative. eVTOL aircraft allow people and cargo, pressed for time, to get to their arrival destinations more quickly as they are able to avoid road congestion. The UAM concept is not totally novel as similar operations to UAM have been conducted since the 1990s using helicopters and therefore, UAM will initially utilize helicopter routes and heliport landing sites.

Today you will be viewing a series of short flights, in which we ask that you act as a remote UAM pilot who is operating a highly automated eVTOL aircraft from a ground control station. All of the weather presented in the following scenarios are within VFR minimums. Please attempt to disregard your own personal minimums and put yourself in the mindset of an experienced eVTOL pilot. You will view a video of each flight followed by a short electronic survey and a short final survey. The entire process will take approximately 20-25 minutes. It is recommended that you complete this task on a laptop or desktop computer. Remember, your participation in this study is voluntary and you may withdraw from the study at any time, for any reason.

Appendix D

Demographics

Age ____________

Biological Sex at birth:

- ○ Male (1)
- ○ Female (2)
- ○ Prefer not to say (3)

Please specify the race with which you most closely identify:

- ○ White (1)
- ○ Black or African American (2)
- ○ American Indian or Alaska Native (3)
- ○ Asian (4)
- ○ Native Hawaiian or Pacific Islander (5)
- ○ Other (6) ____

Please specify the ethnicity with which you most closely identify:

- ○ Hispanic or Latino (e.g., Cuban, Mexican, Puerto Rican, South or Central American, or other Spanish culture or origin regardless of race) (1)
- ○ Not Hispanic or Latino (2)
- ○ Other (3) ____

Type of Flight Experience:
Select all that apply

- ▢ Manned fixed-wing aircraft (1)
- ▢ Helicopter (2)
- ▢ UAS (3)
- ▢ None (4)

Skip To: End of Survey If FlightXP = None

Display This Question:

If FlightXP = Manned fixed-wing aircraft

What level of experience do you have flying fixed-wing manned aircraft?

- ○ Less than 1 yr (1)
- ○ 1 year to less than 3 years (2)
- ○ 3 years to less than 5 years (3)
- ○ 5 years or more (4)

Display This Question:

If FlightXP = Helicopter

What level of experience do you have flying rotorcraft?

- ○ Less than 1 yr (1)
- ○ 1 year to less than 3 years (2)
- ○ 3 years to less than 5 years (3)
- ○ 5 years or more (4)

Display This Question:

If FlightXP = UAS

What level of experience do you have flying UAS?

- ○ Less than 1 yr (1)
- ○ 1 year to less than 3 years (2)
- ○ 3 years to less than 5 years (3)
- ○ 5 years or more (4)

Flight Hours:

Report number of flight hours for the aircraft you have most experience in:

____

What level of experience do you have playing video games?

- Less than 1 yr (1)
- 1 year to less than 3 years (2)
- 3 years to less than 5 years (3)
- 5 years or more (4)

How frequently do you play video games?

- Multiple times a day (1)
- Daily (2)
- Weekly (3)
- Monthly (4)
- Yearly (5)
- Never (6)

Have you taken the Urban Air Mobility Ecosystem: AVT 5201-W01 course at Florida Tech?

- Yes (1)
- No (2)

Appendix E

Task

For this entire study, imagine you are a remote pilot for a small UAM airline, operating VFR flights. You are responsible for one route between JFK's Helipad and Manhattan Helicopters Heliport (pictured first below). At times you are transporting cargo for Amazon's warehouse, other times you are transporting passengers. Prior to starting your flight, you will be informed of your altitude, speed, payload, arrival site, and the weather at the arrival site.

You will then monitor a video of your flight, which will start in the air with visuals of the multifunction display with your flight plan, the windscreen and an overlay with heading, altitude and airspeed. Your goal is to monitor your route, airspeed, and altitude (outlined in red in second picture below) while also scanning out the windscreen. Once the video is complete, you will select the next button.

Page Break

Your mission in the upcoming scenario is to transport four passengers from the Manhattan Helicopter's Heliport southeast to their destination at JFK's helipad near terminal 8. Your scenario begins with the conditions listed below and your aircraft beginning its descent to 1000 feet.

Cruise			Weather		
Altitude	Speed	Cloud	Visibility	Precipitation	Wind
1278	41	Clear of Clouds	Just over 1 sm	Moderate Precipitation	9 knots

Page Break

Watch the full video below before advancing to the next page. It is recommended that once you start the video, you make the video full screen and **<u>select the highest quality viewing option from the settings (the gear icon located on the bottom right of the video window)</u>** for optimal viewing of the flight. Once the video is complete, exit out of full screen mode and click the arrow button to received your arrival weather update.

Your arrival weather update informs you of the conditions listed below with winds forecasted to increase.

	Weather		
Cloud	Visibility	Precipitation	Wind
Developing at 2000 feet	1 sm	Light Precipitation	10 knots

Categorical Decision Outcome (No Frame Example)

Please select a decision from the options below:

- ○ Continue to Destination Site (1)
- ○ Return to Departure Site (0)

Page Break

Continuous Decision Outcome

Select the rating below that characterizes the decision you made to either continue or return in the last scenario you completed.

- ○ Highly Agree to Divert (1)
- ○ Agree to Divert (2)
- ○ Neither agree to Divert or Continue (3)
- ○ Agree to Continue (4)
- ○ Highly Agree to Continue (5)

Appendix F

NASA-TLX Workload Measure

Read each statement and then select the appropriate choice that corresponds to how you were feeling during the task you just completed.

Mental Demand
How mentally demanding was the task?

Very Low	○ ○	Very High

Physical Demand
How physically demanding was the task?

Very Low	○ ○	Very High

Temporal Demand
How hurries or rushed was the pace of the task?

Very Low	○ ○	Very High

Performance
How successful were you in accomplishing what you were asked to do?

Perfect	○ ○	Failure

Effort
How hard did you have to work to accomplish your level of performance?

Very Low	○ ○	Very High

Frustration
How insecure, discouraged, irritated, stressed, and annoyed were you?

Very Low	○ ○	Very High

Appendix G

Risk Propensity Scale

developed by Meertens and Lion (2008)

Directions: Please indicate the extent to which you agree or disagree with the following statement by filling in the option you prefer. Please do not think too long before answering; usually, your first inclination is also the best one.

Items:

1. Safety first.

Totally Disagree								Totally Agree
1	2	3	4	5	6	7	8	9
○	○	○	○	○	○	○	○	○

2. I do not take risks with my health.

Totally Disagree								Totally Agree
1	2	3	4	5	6	7	8	9
○	○	○	○	○	○	○	○	○

3. I prefer to avoid risks.

Totally Disagree								Totally Agree
1	2	3	4	5	6	7	8	9
○	○	○	○	○	○	○	○	○

4. I take risks regularly.

Totally Disagree								Totally Agree
1	2	3	4	5	6	7	8	9
○	○	○	○	○	○	○	○	○

5. I really dislike not knowing what is going to happen.

Totally Disagree								Totally Agree
1	2	3	4	5	6	7	8	9
○	○	○	○	○	○	○	○	○

6. I usually view risks as a challenge.

Totally Disagree								Totally Agree
1	2	3	4	5	6	7	8	9
○	○	○	○	○	○	○	○	○

7. I view myself as a . . .

Risk Avoider								Risk Seeker
1	2	3	4	5	6	7	8	9
○	○	○	○	○	○	○	○	○

Scoring: Each item is scored on a 9-point scale. Items 1, 2, 3 and 4 are reverse scored. Higher scores indicate higher risk-seeking tendencies.

Appendix H

What

- ○ Low Risk (1)
- ○ Medium Risk (2)
- ○ High Risk (3)

What level of risk would you assign to moderate precipitation?

- ○ Low Risk (1)
- ○ Medium Risk (2)
- ○ High Risk (3)

What level of risk would you assign to marginal visibility due to clouds?

- ○ Low Risk (1)
- ○ Medium Risk (2)
- ○ High Risk (3)

Input ID number:

____

Appendix I

Frame Type	Decision Options	
	Risk-Averse	Risk-Seeking
No Frame	Return to the departure site	Continue to the destination site
	Return to the departure site	Continue to the destination site
Gain Frame	Return to the departure site, this will ensure the aircraft is safe. Returning will also ensure amazon crates are intact. The amazon warehouse and your company will recognize your commitment to the safety of your cargo.	Continue to the destination site, the chances of a safe on-time arrival for the amazon crates aboard the aircraft although uncertain, is likely. Amazon's expectations will be met, and you will continue your exemplary record for meeting Amazon delivery demands.
	Return to the departure site, this will ensure the Amazon employees are assured their crates for delivery are safe. The deliveries inside the amazon crates will arrive intact, and your record as an accident-free UAM pilot will remain untarnished.	Continue to the destination site, where the weather may still be mild enough for a safe landing and although uncertain, the aircraft and amazon crates will likely arrive to their destination on time. Your next set of amazon crate deliveries will also be on-time and you'll meet the flight schedule that the company has committed to achieve
Loss Frame	Continue to the destination site, where the chance that the flight conditions are unsafe for landing is very unlikely. The chances that the conditions cause Amazon crates to get damaged is also very unlikely. Continuing the flight may cause your company to have to compensate Amazon for damaged crates.	Return to the departure site, where late amazon crates will cause the company to have to cancel or reschedule the next Amazon deliveries, and this will impact the rest of the flights along your route. Your company will be disappointed in your inability to stay on schedule.
	Continue to the destination site, where the weather is uncertain and flying conditions may yield turbulence. Amazon warehouse employees may be concerned, and your company may consider your decision reckless	Return to the departure site, where amazon crates will certainly be late to their destination, amazon warehouse employees will be upset, and your company will have to compensate the customer

Appendix J

Scenario 1

Cruise			Weather		
Altitude	Speed	Cloud	Visibility	Precipitation	Wind
1436	46 knots	Clouds at 3000 feet	½ sm	Light	10 knots

	Weather		
Cloud	Visibility	Precipitation	Wind
Developing at 2000 feet	1 sm	Light	10 knots

Scenario 2

Cruise			Weather		
Altitude	Speed	Cloud	Visibility	Precipitation	Wind
1278	41 knots	Clear of Clouds	Just over 1 sm	Moderate	9 knots

	Weather		
Cloud	Visibility	Precipitation	Wind
Clear of Clouds	½ sm	Moderate	9 knots

Scenario 3

Cruise			Weather		
Altitude	Speed	Cloud	Visibility	Precipitation	Wind
1422	51 knots	Clear of Clouds	1 sm	Light	11 knots

	Weather		
Cloud	Visibility	Precipitation	Wind
Clouds at 2000 ft	1 sm	Light Precipitation	16 knots

Scenario 4

Cruise			Weather		
Altitude	Speed	Cloud	Visibility	Precipitation	Wind
1007	40 knots	Clear of Clouds	Just over ½ sm	Moderate	13 knots

	Weather		
Cloud	Visibility	Precipitation	Wind
Clear of Clouds	Just over ½ sm	Moderate	15 knots

Scenario 5

Cruise			Weather		
Altitude	Speed	Cloud	Visibility	Precipitation	Wind
1400	40 knots	Clear of Clouds	1 sm	Moderate	14 knots

	Weather		
Cloud	Visibility	Precipitation	Wind
Clear of Clouds	½ sm	Light	15 knots

Scenario 6

Cruise			Weather		
Altitude	Speed	Cloud	Visibility	Precipitation	Wind
1538	31 knots	Clear of Clouds	Just over 1 sm	Moderate	9 knots

	Weather		
Cloud	Visibility	Precipitation	Wind
Clouds developing 2000 feet above	1 sm	Moderate	9 knots