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THE ROLE OF RISK IN AVIATION DECISION MAKING: How Pilots Perceive and Manage Flight Risks

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The current direction in CRM training is threat and error management. In order to manage threats and to prevent them from leading to unsafe situations, pilots must first assess the risks associated with them. Risk assessment feeds into decision making in two ways: during assessment of the precipitating event (or threat) that requires a decision to be made, and in evaluating potential courses of action. Survey data were collected from over 100 airline pilots concerning their everyday experience with five types of risk: *economic, physical, productivity, professional*, and *social*. These risks may be pitted against each other, creating goal conflicts and decision dilemmas. Data from this study are helping us to understand what risks are salient to pilots in everyday flight and how pilots manage those risks when making decisions.

BACKGROUND

The current direction in CRM training for flight crews is threat and error management (Gunther, 2001; Helmreich, Klinecht, & Wilhelm, 2001). In order to manage threats and to prevent them from leading to unsafe situations, pilots must first assess the risks associated with them. A traditional definition of risk is "the possibility of loss," or the occurrence of an undesired consequence. Two factors combine to determine how significant a loss is: the *probability* of the loss and the *magnitude* of the loss (Yates & Stone, 1992). For example, if you are considering an investment in the stock market and you learn that one stock has a 5% chance of dropping while the other has a 25% chance of dropping, you might be inclined to choose the first one. In addition, the amount you already have invested when an advisor warns you of a 25% chance that the stock will drop will probably affect your eagerness to sell it: If you have invested $25,000 you may respond differently than if you have only $5,000 invested.

Although both probability and magnitude of loss are relevant, the significance of a risk is not just a statistical phenomenon. It depends on one's reference point. If you have a recent inheritance, you may be less interested in taking a risk to win a substantial sum than if you have just lost your job. Loss is inherently subjective; the meaning of the loss or gain depends on one's perspective. For example, pilots and air traffic controllers may see the same traffic situation very differently based on their particular experience, goals, sense of control and vulnerability. An experienced instrument-qualified pilot will see a weather system quite differently than will a newly certified non-instrument rated private pilot.

Slovic (1987) has studied factors that influence how people perceive risks and has found a consistent set across many cultures, despite surface variations. First, risk perception depends on the amount of experience or familiarity people have with a situation. More familiarity generally translates into a lower estimation of risk level. Second is personal vulnerability: can this risk hurt me? Clearly, pilots have greater vulnerability than do controllers. Third is the level of control one exercises over a situation. Many people are afraid to fly because they feel totally out of control. They would rather drive a car than be a passenger. Finally, the time frame of a risk is important. Consequences that will occur in the immediate future loom larger than those more distant in time.

Why Study Risk in Aviation?

Despite its apparent significance to aviation safety, there is surprisingly little research on the role of risk perception in pilot decision making. Most of the existing work deals with general aviation pilots (O'Hare and Smitheram, 1995), either in weather-related decision situations or in setting "personal minimums" (e.g., Jensen, 1995). Our interest in studying risk perception was prompted by three

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factors. First, a sorting study designed to identify similarities in problem structuring by commercial airline captains and first officers found that *potential risk* was the most salient dimension for captains but not for first officers, regardless of years of experience (Fischer, Orasanu, & Wich, 1995).

Second, examination of tactical decision errors (TDE) in hull-loss accidents (National Transportation Safety Board, 1994) indicated that 73% of the TDE could be classified as "plan continuation errors" (Orasanu, Martin & Davison, in press). These are errors that occur when pilots continue with their original plan of action, even though conditions have changed or an event has occurred that suggests updating their situation model and reconsidering the plan. Most of these cases occurred during the approach and landing phases of flight, when workload was high, time was limited, and there was little margin for error. Pilots' behavior appears to follow March & Shapira's (1987) observation that "managers pursue risky actions because they fail to perceive accurately the risks involved" (p. 333.) In dynamic situations, pilots may not realize that they need to update their model, they may underestimate the risk associated with the changing conditions, or they may overestimate their ability to cope with the situation.

A third reason for studying risk is that although we have observed little explicit discussion of risk (either during jumpseat rides, in cockpit voice recorder transcripts from accidents, or in crew conversations in full-mission simulations), pilots clearly do assess risk in flight situations. In a full-mission study designed to determine pilots' strategies for correcting an error committed by a confederate pilot, the levels of risk associated with the errors were varied. When risk levels were high, both first officers and captains caught more errors and were more effective in what they said to correct the errors (Orasanu, van Aken, McDonnell & Fischer, 2001) than when risk was low. In addition, Rhoda and Pawlak (1999) found that the likelihood of pilots penetrating thunderstorms in terminal areas reflected the severity of the storms.

Many Types of Risk

A conversation with pilots about the risks they perceive in flight suggests that they are concerned not only about flight safety, but also about passenger satisfaction, fuel consumption, and the legality of their actions. The research literature supports this diversity. Several researchers have pointed out that there are several types of risk: physical harm, professional, economic, social, and psychological (Jacoby & Kaplan, 1972; Nygren, 1995). Moreover, these risks may occur in the same situation and be pitted against one another. For example, a pilot may want to get his passengers to their destination on Christmas Eve, but may face delays in getting there due to bad weather. An airport curfew and low fuel may create a dilemma: to hold and hope to get in before the curfew and a fuel critical situation arises, or to divert and avoid the uncertainty (Fischer & Orasanu, 2001). Risks in this situation include productivity (getting passengers where they want to go at an important time), safety (possibility of running out of fuel), and economic (hotels/meals for passengers at the divert location and then transporting them to their original destination). The decision made by the crew involves balancing these risks and deciding which are most important at that particular time. As Nygren (1995) pointed out, risk dimensions are additive: as the number of risks increases, the more complicated the decision problem becomes.

STUDIES OF AVIATION RISK

We are presently conducting several studies to address two central issues: First, what risks are of greatest concern to pilots? Second, why do they take risks? The first question was addressed by a survey conducted with pilots from a major US carrier. The second issue was addressed in a think-aloud study with a second major carrier that used evolving decision dilemmas. Pilots' risk framing and information use helped to determine their decision strategies.

Risk Survey Method

The survey included three open-ended questions, ratings of frequency of encounters with five types of risk, and requests for descriptions of actual experience with the same five types of risk. The three open-ended questions were: (1) *When you think of risk in your professional life, what concerns or issues come to mind?* (2) *Please describe a difficult professional decision and what made it difficult.* (3) *Have you experienced a flight situation that generated real fear or anxiety? Please describe it.* Demographic information also was collected. Booklets were either distributed personally at the carrier's Operations Center or were placed in pilots' mailboxes and were then returned by mail. To date, 101 replies have been received and 64 have been coded (from 26 captains and 38 first officers).

The rationale for the structure of the survey is as follows: for pilots to make "good" and safe decisions they must be aware of the risks they face. When one faces risks every day, sensitivity to risk becomes part of one's perceptual filter. Thus, the first survey question (*"When you think of risk in your professional life, what concerns or issues come to mind?")* sought to determine which risks were most salient to pilots.

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Second, we wanted to know whether the salience of various risks detected in the first question reflects the frequency of pilots' encounters with them. Pilots were asked to indicate on a scale from *one* to *five* how often they encountered each of five types of risk (economic, physical harm, productivity, professional, and social). Third, we were interested in the specific types of events that pilots actually encountered within each risk category. Pilots were asked to describe situations they had personally experienced that dealt with each of the five types of risk. Finally, we wanted pilots' perceptions about the factors that make their decisions difficult, the second open-ended question.

The five different types of risk in the survey were defined as follows:

Economic: Actions that may have negative economic consequences for your flight, such as fuel usage or missed passenger connections.

Physical: Professional actions that may have negative consequences for flight and passenger and safety.

Productivity: Actions that may have productivity consequences, such as delaying a flight departure or arrival, or rejecting a placarded aircraft.

Professional: Actions whose consequences could negatively impact career goals or job security.

Social: Actions that may negatively impact how others (e.g., pilots, managers, controllers, passengers, flight attendants) judge your competence and skill.

Results

Responses to only three items will be reported here: open-ended question 1, frequency of encounter ratings, and difficulty explanations, in that order.

Q1: When you think of risk in your professional life, what concerns or issues come to mind?

Pilots' responses to the first question were sorted into one of the five risk categories described above. Items were sorted by outcomes or consequences, all of which are losses of some type (e.g., safety, job, money, respect). All responses fit into these five categories, though some categories were quite diverse. Examples of responses in each of the five risk categories are shown in Figure 1. The examples typically reflect *causes* of a type of loss. These are specific operational issues that can have distinct consequences for pilots.

Figure 1. Examples of Responses in each Risk Category

Economic

Passenger missed connections due to medical emergency or delayed feeder flight.

Physical

Fear of making a bad decision, not managing risk. Deferred maintenance, substandard de-icing facilities, high traffic density, runway collision, jammed radio frequencies, terrorism, turbulence, fatigue, terrain.

Productivity

Delays associated with weather or ATC, rejecting an unsuitable aircraft.

Professional

Will I correctly handle my next check ride? Being charged with a crime, losing medical certificate or job.

Social

Telling a captain to go around or divert, reporting a junior officer. Making a smooth landing.

The majority of responses reflected concerns with safety: 77% of responses fell into the physical risk category. Concerns with job security ranked a distant second, with 18% of responses falling into professional risk. Thus, these two categories accounted for 95% of the responses, with the remainder distributed across the other three.

Physical risk. While all responses in this category were concerned with the possibility of physical harm, the *sources* of the physical risks were quite diverse. Most frequent for both captains and first officers were self-referential responses that we labeled "individual" factors. These refer to the possibility that one's own behavior may contribute to a reduction of safety. Approximately one- third of the physical risk responses fell into this category. Pilots (particularly captains) referred to their own ability to manage risks and to make good decisions. Most first officers' "individual" responses referred to their physical health or fatigue as safety-compromising factors. These crew differences may reflect differing crew responsibilities and experiences.

The next two subcategories contributing to physical risks were *environmental* factors and *aircraft equipment*. Typical environmental factors were weather and turbulence (especially important to captains), traffic and midair collisions, and general uncertainty about environmental events. Both captains and first officers were concerned with aircraft equipment failures, automation problems, and fire or smoke. Together these two factors accounted for another 35% of the physical risk responses.

Professional risk. The second most commonly mentioned concern expressed by the pilots dealt with the risk of losing their jobs due either to medical conditions that would affect their license or to legal violations that would result in FAA actions. This type of concern was expressed slightly more often by first officers than by captains (21% vs. 14%).

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Frequency of Encounters with Various Types of Risks

Rating Scale: "How often do you feel each type of risk plays a role in decisions you are routinely called upon to make as a pilot?"(Rate from 1 to 5)

Given the pattern of findings for relative salience of risk concerns to pilots, the second question was whether risk salience reflects frequency of encounters with the various types of risks. Pilots were asked to indicate on a scale from one to five how often they needed to consider each type of risk when making flight decisions. As shown in Table 1, frequency of encounter clearly was not related to salience of risk concerns. No statistical differences were found between captains and first officers.

Table 1. Mean Ratings of Frequency of Encounter with Various Types of Risk

Risk Type	Mean Frequency Rating (from 1 to 5)
Productivity	2.9
Economic	2.8
Professional	2.6
Physical	2.3
Social	2.3

Pilots reported encountering productivity, economic and professional risks most frequently. Physical safety risks, which dominated pilots' concerns, were reported to be encountered less frequently and did not differ significantly from social risks. Hence, pilots' concerns with various types of risks clearly do not reflect how often they encounter those risks in actual decision making situations.

What Makes Decisions Difficult?

Q2: "Please describe a very difficult decision you have had to make as a professional pilot and what made it difficult."

In this question we sought to determine whether pilots' perceptions of what makes decisions difficult corresponded with predictions of decision difficulty based on our aviation decision process model (Orasanu & Fischer, 1997). Pilots' responses were categorized according to their consequences. Three major categories emerged: safety, cognitive effort, and career/personal, as shown in Table 2. [Note: Not all pilots responded to this question.]

Within safety the most common response involved goal conflicts, primarily those that pitted safety against achieving passenger satisfaction (e.g., getting them to their destination on time). A second subcategory referred to conflicts in which there was no good option (e.g., destination is closed due to weather, alternate weather is deteriorating, and fuel is low). These decisions often involve risk trade-offs. Both captains and first officers reported this source of difficulty.

Table 2. Frequency of Mention of Factors Contributing to Decision Difficulty

Contributing Factor	Captains (N= 26)	First officers (N = 38)
Safety	10	11
Cognitive Effort	9	3
Career/Personal	3	15

The second category is essentially metacognitive. It refers to difficulty arising from heavy workload, time pressure, or the uncertainty inherent in many decision situations. Captains, who are responsible for making decisions, were more sensitive to this factor than first officers. Factors relating to career choices, personal health and well being were mentioned primarily by first officers.

EVOLVING DECISION DILEMMAS

Why pilots make risky decisions, our second major issue, was addressed through think-aloud protocols for dynamically evolving decision problems (see Fischer and Orasanu, 2001, for details). Two scenarios were developed that created dilemmas for pilots. The first was a take-off scenario involving wind-shear reported by landing aircraft and 20 planes in line behind the participant's aircraft. The second involved approach and landing on Christmas Eve with holding due to traffic, bad weather, a destination curfew, and low fuel. In each case, there were risks associated with both continuing with the original plan (the riskier choice but the greater payoff) and delaying take-off or diverting (the less risky choices). Pilots read the first stage of a scenario and were asked to think aloud, verbalizing their concerns and information needs, and to make a decision at each stage. They proceeded this way through each of the sequential steps of the scenario.

Results

Analysis of 30 pilots' responses (17 captains and 13 first officers) indicated that in fact the problems represented decision dilemmas. Half of the pilots diverted or delayed takeoff and half continued with the original plan. Individual pilots were not

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consistent; most continued on one scenario and changed their plan on the other. No evidence was found for either risk-taking or risk-averse personal styles. That is, pilots did not consistently choose the risk-taking or risk-averse options. Most significantly, how pilots framed the situations seemed to influence which decision they made. If they created a situation model that was clearly negative (there is windshear at the airport, storm is heading toward us), they took the cautious approach. If they painted a picture that was less negative (loss of airspeed is diminishing, my takeoff path is away from the storm), they were more likely to pursue their original course of action. Moreover, continuations were usually accompanied by a strategy to mitigate the risk, such as reviewing windshear procedures prior to takeoff or declaring a fuel emergency and requesting special handling to reduce their holding time.

DISCUSSION

These two studies represent an initial effort to understand the risks that pilots face and why they make the decisions they do. The inherently subjective nature of risk is clearly evident in the differences between captains and first officers in the risk perception survey and in the situation models created by pilots in the think-aloud study. The survey indicated that pilots' main concern was with factors that compromise flight safety. Their recognition of their own possible contribution to loss of safety was unexpected. This was reinforced by the captains' awareness of how cognitive load and uncertainty contribute to decision difficulty.

The decision dilemmas show how decisions reflect pilots' evaluations of risks presented by the situation. The extent to which pilots considered the conditions risky influenced their willingness to continue with their original plan. Coupled with their risk assessment was the extent to which they felt they could control the risks associated with various choices. Preparations for windshear and ATC special handling were associated with accepting the riskier option. How risk perception affects decision strategies by pilots with varying levels of experience and under diverse conditions is a topic that we are investigating further.

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