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Differences in risk perception between pilots and air traffic controllers

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**DIFFERENCES IN RISK PERCEPTION BETWEEN PILOTS AND AIR TRAFFIC
CONTROLLERS**

A Thesis

Presented to

**The Faculty of the Department of Psychology
San Jose State University**

In Partial Fulfillment

**of the Requirements for the Degree
Master of Arts**

by

Jeannie Davison

May 2002

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Differences In Risk Perception between Pilots and Air Traffic Controllers

Jeannie Davison

San Jose State University

Running Head: DIFFERENCES IN RISK PERCEPTION

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Abstract

One of the greatest challenges facing the aviation industry today is the continued growth of traffic, often overwhelming the air traffic control (ATC) system at the busiest airports, especially during periods of inclement weather. One concept under consideration to accommodate this growth is a more flexible ATC system, known as free flight, which would allow user-preferred routing and limited pilot self-separation. This thesis considers the difference in risk perception reported by pilots and air traffic controllers in the existing ATC system, and under a simulated free flight environment. No significant differences in risk ratings were found for role or ATC Environment, although significant differences were found when the varying traffic situations were considered. In addition, pilots and controllers indicated that they prefer to use different types of maneuvers to resolve traffic conflicts. This information will aid in the development of new policies and procedures in the evolving air traffic management system.

Differences In Risk Perception Between Pilots And Air Traffic Controllers

This study is concerned with the ability of expert pilots and air traffic controllers to perceive and quantify risk, and with identifying factors that may affect risk perception. An additional purpose is to determine whether there are differences in risk perception that may result from the varying perspective each group brings to the aviation system. The National Airspace System (NAS) faces continual traffic growth, which often overwhelms the air traffic control (ATC) system at the busiest airports, especially during periods of inclement weather. One concept under consideration to accommodate this growth is a more flexible ATC system, known as Free Flight, which would allow user-preferred routing and limited pilot self-separation. An additional question addressed by this study is how the free flight goals of relaxing restrictions on aircraft routing and altitude assignments will impact the roles and responsibilities of pilots and air traffic controllers, as well as the safety of the NAS.

Risk is a normal feature of everyday life, from crossing the street to driving a car, and the aviation system is no exception. Risk has been defined in many ways, but most researchers agree that it is a combination of the probability of an occurrence with the magnitude of actual negative events (Brehmer, 1987; Brehmer, 1994; Rasmussen, 1987; Yates & Stone, 1992). Risk assessment involves recognition of risk and an analysis of the consequences of the situation, and is usually followed by some choice or decision (Pidgeon, 1988; Rasmussen; Slovic, Fischhoff, & Lichtenstein, 1982).

Important considerations in risk perception are the different methods used and results obtained by experts such as pilots and air traffic controllers, in contrast with the general public. With their greater experience and exposure to the relevant domain, experts are

usually better able to evaluate a situation and may perceive risks differently (Slovic et al., 1982). However, like the general public, experts are subject to the influences that cause errors in judgment, such as faulty heuristics (e.g., availability or recency) and misleading personal experiences (Christensen-Szalanski, Beck, Christensen-Szalanski, & Koepsell, 1983; Rasmussen, 1987; Slovic, 1987; Slovic, 1994).

The ability of flight crews to assess the level of risk in a situation has been identified as a critical element in aviation decision making, and may be one component in a number of aircraft accidents (National Transportation Safety Board, 1994; Orasanu, 1995; Orasanu, Dismukes, & Fischer, 1993). Pilots and air traffic controllers are continually required to assess risk and make decisions based on those assessments, so an understanding of the elements that affect risk perception in aviation is critical to any attempt to modify the air traffic control system.

Research and measurement of risk perception and assessment

A large body of research exists on risk in other domains, such as decision making, new technologies, and the nuclear and chemical industries (e.g., Brehmer, 1987; Flin, Mearns, & Fleming, 1996; Mearns & Flin, 1995; Slovic, 1994). The results from these studies indicate that risk can be quantified, that experts and novices differ in their estimation of risk, and that experts with different perspectives, such as pilots and controllers, also differ in their assessment of a given situation (e.g., Kuyper & Vlek, 1984; Pidgeon, 1988; Savage, 1993).

Quantifying risk. Yates and Stone (1992) identified the elements of risk as *losses*, *significance*, *uncertainty*, and *overall risk*, all aspects relevant to the aviation industry. The most apparent losses in the aviation industry are those resulting from an aircraft

accident, but there are other, less obvious losses that may influence flight crew decision making. Air traffic delays, in-flight diversions, and cancellations due to mechanical failures may all lead to extra fuel usage and passenger inconvenience, resulting in economic loss to the airline. While not as significant as the outcome of an accident, economic and productivity losses can have a major impact on the ability of an airline to remain competitive in an industry with a very low profit margin. According to the Air Transport Association (ATA), the net profit margin in the airline industry was merely 2% in 2000, down from 4.3 – 4.7% in the previous three years (2002b). The ATA reports that aviation fuel is the largest supply expenditure made by airlines, accounting for 10-15% of their total annual expenditures, exceeding \$10 billion in 1998 (2001), so even short in-flight diversions can have a major impact on the economic health of an airline. In the year 2000, delays cost the airline industry \$3.2 billion in direct costs, plus another \$3.2 billion in indirect costs (ATA, 2002a). While the air traffic controllers' primary task is to safely separate traffic, pilots' are faced daily with conflicting goals: safety is their highest priority, but they must also consider economic and productivity factors when making decisions.

Research by Savage (1993) has identified three psychometric attitudes toward risk and the hazards that may generate risk. The three risk dimensions identified by Savage include *Dread*, whether the risk is *Known*, and *Personal Exposure* to the risk. In risk perception studies by Slovic, the hazards presented for judgment are grouped using factor analysis into two factors: *Dread* and *Unknown Risk* (1987). Each of these elements may be germane in an aircraft accident, especially when examining differences between pilots and controllers. The personal exposure dimension is particularly relevant to pilots, as

they are physically at risk in flight. In a survey regarding pilots' judgments of risk in aviation, both personal vulnerability and uncertainty, or unknown risk, were identified as factors that make aeronautical decision making more difficult (Orasanu, Davison, & Fischer, 2001). In addition, the element of dread may influence the risk perception of both pilots and controllers, especially due to the considerable amount of media attention given to aircraft accidents over the past few years and the horrific visual images displayed endlessly on all-news television stations.

Another area of risk research involves studying risk aversion and risk-taking behavior. These studies usually involve gambling behavior, using money as a quantifier, or computer simulations using novice participants such as college students (Hollenbeck, Ilgen, Phillips, & Hedlund, 1994; Kuyper & Vlek, 1984; Lopes, 1983; Lopes & Casey, 1994). While these studies are limited in their relevance to the aviation industry, they do provide some valuable background information to guide development of risk perception studies.

Differences due to expertise. Risk research specific to the aviation system includes perceived probability of mid-air collision, responses to perceived risks, and perception of risks and hazards in General Aviation, as well as simulated free flight conditions involving both pilots and air traffic controllers (e.g., Ellis, McGreevy, & Hitchcock, 1984; Ellis & Palmer, 1982; O'Hare, 1990; Remington, Johnston, Ruthruff, Romera, & Gold, 2000; Shuch, 1992). In his study of General Aviation pilots, O'Hare found that older pilots (defined as 30+ years of age) rated the personal risks involved in flying as very low, whereas younger pilots (under 30 years of age) rated the risks as higher. In addition, younger pilots were likely to rate their skill and judgment abilities as highly as

did older pilots. In a study utilizing LaPlace's Law of Succession, Shuch calculated pilots' perceptions of collision probability and hypothesized that repeated flights without incident might lead pilots to lower their estimate of collision probability. This in turn may lead to complacency and a decrease in external scanning for other aircraft. Contrary to Shuch's theory, the results of a survey administered to over 1,000 professional airline pilots indicate that they actually perceive midair collision as one of the leading hazards they face in their job (Moses & Savage, 1989). Orasanu et al. also found that pilots were concerned about the risk of mid-air collisions (2001). Based on these findings, pilots may judge risk to be higher in situations with aircraft in close proximity, and hence, a higher likelihood of a mid-air collision.

Remington et al. (2000) conducted a series of part-task free flight experiments to determine how relaxing constraints on routes and altitudes would affect the ability of air traffic controllers to accurately detect traffic conflicts. They found that traffic load and conflict geometry¹ consistently affected time to detect a conflict, but there was little effect due to the removal of altitude and route restrictions. The current study used a similar task and manipulated traffic density as well as route restrictions, so risk ratings given by controllers may follow a similar pattern to those found by Remington et al. In a series of experiments conducted at NASA Ames Research Center using Cockpit Displays of Traffic Information (CDTI), it was found that as time to minimum separation decreased, subjective threat increased significantly (Ellis & Palmer, 1982). This result appears reasonable, as there is greater risk of a collision as aircraft fly in closer proximity

¹ Conflict geometry included two elements: conflict angle, defined as the angle of convergence for conflict pairs, and conflict time, defined as the length of time before a conflict would occur.

to each other. In a later study, it was found that 86% of the time pilots selected an avoidance maneuver at least 30 seconds prior to the point of minimum separation between aircraft, which is before an automatic collision avoidance device would be expected to provide a positive avoidance command. For those responses within 30 seconds of the point of minimum separation, the minimum distance between the aircraft was calculated to be at least 1.5 nautical miles. In response to the most threatening situations (small minimum distances between the aircraft), the pilots nearly always responded earlier in the scenario. It was also found that the response timing was affected by when the intruding aircraft appeared on the screen in relation to the point of minimum separation (Smith, Ellis, & Lee, 1984).

Several studies of CDTI devices revealed that pilots tend to turn toward intruding aircraft, decreasing separation (Ellis et al., 1984; Ellis & Palmer; Smith et al.). This response, which differs from the guidance that would be recommended by automatic collision avoidance systems, was less likely in instances when the participants perceived greater danger or when provided with a perspective view of traffic rather than simply a plan view (Smith et al.). Ellis and Palmer theorized that the pilots turned towards the intruder aircraft much as they would when trying to keep traffic in sight under visual flight conditions. Like the Remington et al. (2000) results, the findings from these studies may be similar to those revealed in the current study, with higher risk ratings as traffic gets closer to the participants' aircraft.

Further research has been conducted at NASA Ames Research Center to determine how effectively flight crews can achieve self-separation (Cashion, Mackintosh, McGann, & Lozito, 1997; Lozito et al., 2000). In a series of full-mission simulation studies, it was

determined that flight crews were able to maintain separation if provided with a CDTI and conflict alerts. Using distances of 5 nautical miles lateral and 1000 feet vertical separation, flight crews were successful in nearly all trials, with few losses of standard separation² (LOSS). In the trials where a LOSS did occur, the crews had maneuvered to provide separation from another aircraft but returned to the original flight path too soon or failed to reach the altitude required to accomplish vertical separation, resulting in minor infractions. Flight crews were most likely to use heading maneuvers, followed by speed adjustments, and finally altitude to avoid conflicts. Communication preferences were also examined, and Cashion et al. found that when given the option, crews were much more likely to communicate with the other aircraft than with the controller. It was anticipated that the findings from these studies would be replicated in the current study.

In a study using a hypothetical decision-making exercise, Fischer, Orasanu, and Wich (1995) had pilots sort scenarios according to the major decision required to resolve the problem presented. Results indicated that captains were more likely than junior officers to consider risk when faced with making decisions. This may be related to captains' higher experience level or the different goals and responsibilities of captains as compared to junior officers. While the current study did not specifically examine differences between captains and first officers, it is anticipated that differences in the goals and responsibilities of pilots and controllers may lead to differences in their risk perception, and therefore their ratings.

² A loss of standard separation occurs when two aircraft flying in closer proximity to each other than the standard established for that airspace, providing an appropriate safety margin.

Results of the research presented indicate that risk is a construct that can be identified and quantified. Risk perception is a key component in decision making, especially in a dynamic environment such as aviation. As the aviation system continues to grow in complexity and traffic level, those responsible for regulation must be made aware of the various users' differing perception of risk and how those differences may affect the users' decisions and actions.

The aviation environment

The research literature presented shows the significance of risk in many fields. To understand how risk and risk perception may affect those involved in aviation, some knowledge about the operation of the aviation environment is necessary. In order to ensure safe flight, pilots and air traffic controllers perform different tasks, using specialized equipment, with regulations and procedures specific to their roles and responsibilities. The differences in the roles, responsibilities, and goals of pilots and air traffic controllers necessitate that they each bring a different perspective to the flight environment. Each individual pilot (or flight crew) is primarily concerned with the safe completion of his or her flight. In addition, the pilot must also be aware of time pressures, economic considerations, passenger comfort, and regulatory constraints. In modern aircraft, pilots are provided with displays to aid navigation, weather avoidance, and collision avoidance, but the displays currently in use do not show general traffic information. In contrast, air traffic controllers are responsible for the separation of all aircraft within their area of responsibility, usually defined as a sector. The air traffic controller's foremost concern is the safe separation of all flights under his or her control and maintaining efficient traffic flow, with regulatory constraints a consideration as well.

The display units used by air traffic controllers present an area of a specific adjustable radius, showing them all aviation traffic within that airspace. This gives the controller a more global perspective on the traffic situation than that afforded pilots by their displays.

There is a new concept that the Federal Aviation Administration (FAA) is considering for air traffic management in the U.S. known as free flight (FAA, 2001a). In a free flight environment, traffic separation during the en route portion of flight may become the responsibility of the pilot rather than the duty of the air traffic controller, who is currently responsible for traffic separation. This will put the controller in the position of a traffic monitor rather than an active traffic manager. To maintain the safety level of the traffic management system, separation distances would likely remain the same; only the responsibility for ensuring safe separation of en route aircraft would be changed.

Under the existing air traffic management system, each airline flight has a flight plan on file with the FAA, which is treated like a contract. In addition, most flight plans follow established FAA preferred routes of flight. Flights are routed in accordance with the filed flight plan and any deviation from the flight plan must be approved by ATC. When operating in a free flight environment, airlines would be free to plan their flights according to the route that is most efficient for their purposes on a given day, and flight crews would be given more freedom to deviate from the flight plan without the need for ATC approval. In order to accomplish this change to the air traffic management system, new traffic displays must be provided for pilots and controllers, new procedures and regulations must be drafted, and the roles and responsibilities of pilots and controllers will change substantially.

Risks in the aviation environment

The aviation system has its own unique set of risks, along with many regulations, procedures, and training methods intended to control and limit exposure to risk.

Although the aviation system is extremely safe, especially in contrast with transportation by automobile, risks do exist and must be considered. One area of particular interest in the aviation industry concerns the introduction of new technology, and the change this technology generates in the way pilots and air traffic controllers perform their jobs (Ellis et al., 1984; Ellis & Palmer, 1982; Smith et al., 1984). As the aviation industry contemplates a transition from the existing traffic management system to a more flexible environment, the introduction of new technologies, along with the development of new regulations and procedures, must be accomplished without creating new risks or increasing those already present. The RTCA Task Force Three (1995), in an advisory capacity, made the following recommendations concerning research to aid free flight implementation:

1. The human factors aspects of separating aircraft with varying minima should be studied, along with the creation of displays and procedures that will be clear to both pilots and controllers.
2. Human perception and responses associated with the time and distance buffers that separate aircraft should be studied.
3. Conduct studies to determine how quickly pilots and controllers are able to detect and resolve traffic conflicts.
4. Determine that proposed changes don't increase perceived hazards, statistical risks, and experienced discomfort (p. 146-147).

As can be seen from previous research, the concept of risk perception has been studied in many fields, but little work has been conducted in the aviation environment. In order to maintain the existing safety level in the U.S. air traffic management system, more research needs to be performed to identify the differences between the participants, especially those that relate to future changes in the aviation environment, such as instituting free flight.

The present study

In the present study, pilots and air traffic controllers were presented with the same traffic scenarios to determine if they perceive the same degree of risk in each scenario, and whether they prefer to use the same maneuvers in response to anticipated conflicts. In addition, the flight condition was varied, with half of the participants basing their responses on the existing, controlled ATC system and the existing regulations. The remaining participants based their responses on a simulated free flight environment, using modified regulations. It was anticipated that as a result of their personal involvement in flight, pilots might rate the amount of physical risk more highly than would controllers, regardless of the flight condition. Due to the strategic nature of their role in the aviation system, it was anticipated that controllers would perceive risk sooner and take action to avoid a conflict earlier than would pilots. Either of these findings would indicate a main effect for the variable of role.

Due to the lack of a body of knowledge on the subject, no prediction on direction of results in the flight condition can be anticipated. It may be that both groups perceive more risk in the free flight condition due to the novelty of the situation or discomfort with their new roles. An interaction may occur such that pilots perceive less risk in the

condition where they have more control over their flight path and the controllers perceive more risk as they give up some control over the situation. In several studies of risk perception, participants reported a lower perception of risk in conditions over which they have control than in situations that are out of their control (Johnson & Tversky, 1984; Pidgeon, 1995; Sjöberg, 1998; Slovic, Fischhoff, & Lichtenstein, 1984; Vlek & Keren, 1992). Although physically in control of their aircraft, pilots in the existing ATC system must request and receive approval from a controller before changing their altitude or heading (except in an emergency). Not only does this shift some control over the flight to the controller, it also compels the pilot to wait for a response before he/she learns whether a request has been approved and can act on the decision. In the extremely busy communication environment of our NAS, this can sometimes entail a considerably long wait, and may increase a pilot's sense of risk. Similarly, controllers have regulatory control over the aircraft in their airspace, but they have no physical control over the aircraft. When a controller requests an aircraft to make some maneuver, he/she must also wait for the decision to be carried out, which might increase risk perception, especially if the requested maneuver was in anticipation of an impending traffic conflict. In a free flight ATC system pilots would be allowed to maneuver as they judge necessary, without waiting for approval from the controller, which may actually decrease their perception of risk. Although the controller would be informed of the new flight path, the loss of control over the aircraft maneuvers may raise the controller's perception of risk, especially if there is a delay between the start of the aircraft maneuver and the controller notification.

Method

Participants

A total of sixty-four aviation professionals took part in the study: 32 pilots from one major U.S. airline and 32 controllers from one U.S. Air Route Traffic Control Center. Participation was voluntary, and participants received financial compensation for their time. Recruitment was accomplished using posters, sign-up sheets, and word of mouth. Participants included 31 male pilots and one female pilot, along with 27 male and 5 female air traffic controllers. The average age of the participants was 41 years of age for the pilots and 41.6 years for the controllers. All of the pilots were on active flight status, and employment with their current airline averaged 6.3 years, ranging from 1 to 25 years. In addition to the years of experience with their current airline, 24 pilots had an average of 14 years of military flight experience, and 20 pilots had an average of 14 years of general aviation flight experience, both of which may overlap with their current airline flight experience. All of the air traffic controllers were full performance level controllers at an en route facility, and averaged 14.5 years of employment with the FAA, ranging from 9 to 25 years. Twenty-four pilots and one controller had military flight experience, and four controllers also had civil flight experience. In addition, four controllers had military experience as air traffic controllers.

Apparatus

The experiment was conducted on a desktop personal computer using a Windows 98© operating system and a Visual Basic© program developed for this project. The study was administered to the controller participants at the local National Air Traffic Controllers Association office and to the pilot participants at their employer's training

center. The combined TCAS/navigational display unit from a B747-400 aircraft simulator was used to generate en route traffic scenarios, which were then photographed to generate the display stimuli (see Figure 1). The eight scenarios were originally designed for use in a full-mission simulator study of flight crew self-separation (Lozito et al., 2000), and were adapted for use in this study.

Photographs of the scenarios were taken at 15-second intervals and shown on the monitor as static snapshots using the same interval. Different traffic situations and varying levels of traffic density were presented in eight different scenarios, ranging from 12 to 25 photos per scenario for a total of 155 photographs. Each snapshot included a Galton scale with a sliding pointer manipulated by the computer mouse, allowing the participant to indicate the level of risk he/she perceived at that point (see Figure 1). In order to limit dependencies or memory interference between the risk ratings on subsequent snapshots, no anchors were displayed on the scale. In addition, an icon labeled Intervene was presented for the participants to click with the mouse when they wished to intervene in the scenario. Once the participant indicated a desire to intervene, questions relevant to his/her role were electronically presented and responses were collected. A more detailed description of the intervention options will be provided in the procedures section.

Design

The project used a 2 (role) x 2 (flight condition) x 2 (traffic density) x 2 (vertical traffic profile) x 2 (intruder proximity) mixed design, with between-subjects variables of role and flight condition. The within-subject variable design is depicted in Table 1.

Figure 1. Sample stimulus presented to participants.

Table 1

Within-subject Variables; Replicated in each Flight Condition

Traffic Density	Vertical Profile	Proximity
High	Level	Near
High	Level	Far
High	Descending	Near
High	Descending	Far
Low	Level	Near
Low	Level	Far
Low	Descending	Near
Low	Descending	Far

Each participant's role was either pilot or air traffic controller, and participants were assigned to a flight condition randomly with the restriction that there be equal numbers in each group. Levels of the flight condition were either controlled or free flight (FF). In the FF condition, pilots were responsible for traffic separation. Traffic density levels were high (15-16 aircraft) or low (7-8 aircraft). In the vertical profile condition, either all aircraft were flying level, or one aircraft was descending. The intruder proximity condition varied the minimum separation distance between the reference aircraft and the primary-conflicting aircraft (near vs. far). The dependent variables were (a) the risk rating that participants assigned to each snapshot, (b) the timing of participant intervention actions, and (c) the maneuvers that participant's selected to avoid an anticipated conflict.

The traffic flew at various altitudes and headings, some level and others descending. In each scenario, one aircraft (the *Target*) flew on a path that decreased the aircraft separation, and either led to a loss of standard separation (LOSS) with the *Reference aircraft* or nearly led to a LOSS. As the scenario progressed, the two aircraft converged

to the point of minimum separation or LOSS. Once this occurred, the flight paths then diverged or the scenario ended. A loss of legal separation occurred any time that two aircraft came within 5 miles horizontal distance and 2,000 feet vertical distance of each other. No midair collisions were programmed, and there was only one aircraft with a flight path leading to a conflict with the reference aircraft in each scenario. If the conflict involved two aircraft flying on a collision course, the target aircraft changed its flight path to avoid a collision after the minimum separation distance had been reached.

Procedure

Procedures were developed with the assistance of two airline pilots and two air traffic controllers, and a pilot study was run with ten pilots and two air traffic controllers at NASA Ames Research Center (Davison & Orasanu, 1999). Results from this pilot study and feedback from the participants were used to finalize the experimental design.

Prior to the experiment, participants were briefed with a description of the study goals, an explanation of the task, and those in the free flight condition were given rules specific to that condition. In addition to verbal instructions, a copy of the free flight right-of-way rules was provided for the participants in the free flight condition to study before beginning the experiment, and to refer back to during their training and experimental trials. All participants received instructions and training to familiarize them with the display (which was more familiar to pilots) and the task (which was more familiar to controllers). A detailed description of the instructions follows. In order to avoid influencing the results, participants were not informed during the briefing that the study included different flight conditions, or that both pilots and air traffic controllers

were included in the study. This information was explained to all participants during the debriefing conducted after they had completed the study.

Risk Rating Task and Instructions. Participants were given written copies of the instructions to follow along while the researcher read the instructions out loud. The following instructions were given to participants to indicate their risk ratings:

Your task is to examine each snapshot and judge how much risk or threat you perceive in the traffic situation with respect to the reference aircraft (located at the 6 o'clock position on Figure 1). Some will have none or very little risk; some will verge on imminent conflict; and others will fall somewhere in between. Separation standards of 5 miles horizontal and 2000' vertical should be considered when making your ratings about how much risk is in the traffic situations depicted on the screen.

Further details were given as follows:

To select your risk rating, please use the mouse on the green bar at the bottom of the screen, clicking the indicator on the point that best represents your perception of the risk in the snapshot **at that moment** -- not potential risk. The LEFT endpoint represents **NO RISK** and the RIGHT endpoint represents **IMMINENT RISK OF LOSS OR A MID-AIR COLLISION**. You may assume a graduated scale from 0 on the left to 100 on the right. Please make each rating independent of the previous snapshots, **based strictly on the risk present in that snapshot** -- not potential risk. Each snapshot will be presented for 15 seconds, so be sure to make

your risk rating selection within the 15 seconds allotted, as the display will continue on to the next snapshot after 15 seconds.

Free Flight briefing. The study was administered the same in both flight conditions with the exception of the pre-experiment briefing of instructions and procedures.

Participants in the controlled flight condition were told that the flights were conducted in a normal ATC environment; hence the rules for maneuvering were not discussed. Pilots in the FF condition were briefed regarding the rules and procedures to use for self-separation, and controllers were told the right-of-way rules and procedures pilots were expected to use for self-separation. Pilots were briefed that they were responsible for self-separation, with controllers monitoring the situation. Controllers were briefed that they had the option to step in and take control when the situation made them uncomfortable or they felt the pilots were not able to maintain separation. The rules pilots were instructed to use in determining which aircraft had responsibility for maneuvering were those used in VFR flight (FAA, 2002). The rules were:

1. **Converging.** When aircraft of the same category are converging at approximately the same altitude (except head-on, or nearly so), the aircraft to the other's right has the right-of-way.
2. **Approaching head-on.** When aircraft are approaching each other head-on, or nearly so, each pilot of each aircraft shall alter course to the right.
3. **Overtaking.** Each aircraft that is being overtaken has the right-of-way and each pilot of an overtaking aircraft shall alter course to the right to pass well clear.

Intervention Task and Instructions. At any point within a scenario, the participant could indicate his/her desire to maneuver to avoid a perceived conflict by clicking on the

Intervene icon. Participants were informed that once they clicked on the Intervene icon, there was no time limit and they could take as long as necessary to determine how they wished to maneuver and indicate their choices. When this occurred, the 15-second time limit was suspended, and the maneuver options screen was presented. This screen allowed the participants to select a maneuver (climb, descend, turn or a combination), and the degree of action needed (angle of turn and rate of vertical movement). Pilots were allowed to maneuver the reference aircraft, and controllers were given the option of directing either or both of the aircraft involved in the conflict to maneuver. In addition to maneuvering the aircraft, participants were asked to indicate their desire to communicate with either the controller or the aircraft, as applicable to their occupation. After answering the maneuver options questions, the scenario continued to its completion, enabling the participant to continue rating the risk in each snapshot. If the participant did not indicate a desire to maneuver, the scenario cycled through all of the snapshots at 15-second intervals until the scenario was completed.

Participants were given the following guidance for intervening to resolve a perceived conflict:

Your second task will be to indicate how you would prefer to respond to the traffic around the reference aircraft, when you judge that some action is warranted. After you have made your risk rating, a button will appear in the lower left hand corner of the screen that says INTERVENE. If you choose to intervene, you will be asked to identify the aircraft that presents a potential conflict with the Reference aircraft.

This will be referred to as the TARGET aircraft. Next, you will be asked about the action you would prefer to take in response to the conflict identified.

Participants were then shown the possible maneuvers available to them, including climb, descend, turn left, turn right, or any combination of vertical and horizontal maneuvers, such as climb and turn right. Each option also included the degree of maneuver desired, such as “Climb 500 fpm or less”, or “turn 15°”.

After the briefing, each participant was trained on the apparatus and allowed to run a minimum of two practice trials. Participants were allowed to repeat the practice trials if necessary to achieve proficiency with the task. Proficiency was judged by the experimenter to be achieved when the participant was able to consistently indicate their risk rating within ten seconds on five consecutive photos, as well as to intervene and respond appropriately to the intervention questions. The experimenter was available during the practice trials to answer questions and to ensure that the participant was performing the task according to the instructions.

Most participants required approximately 45-55 minutes to complete the eight scenarios. The duration of the experiment, including pre-briefing, practice trials, experimental trials, and debriefing required approximately 1 1/2 to 2 hours to complete.

Results

This study tested the following hypotheses:

1. Pilots and controllers will rate risk differently, with pilots rating risk higher than controllers.
2. Differences in risk ratings will be found between the flight conditions, although the direction of those differences cannot be anticipated.
3. Controllers will perceive and rate risk sooner and intervene earlier than will pilots.

4. Pilots and controllers will use different maneuvers in response to anticipated conflicts.

A comparison of pilots' and controllers' mean risk ratings was used to assess effects based on role and flight condition. Risk rating response times were analyzed to assess whether controllers perceived risk sooner than did pilots in this study. To reveal whether controllers intervened earlier in the scenarios than the pilots, the point in each scenario when each participant intervened was analyzed. Finally, the selected intervene maneuvers were used in an analysis to determine whether the two groups preferred to use different maneuvers to resolve anticipated conflicts.

The risk ratings and response times were analyzed separately using mixed analyses of variance, with role and flight condition entered as between-subjects variables, and the three traffic conditions (proximity, vertical profile, and traffic density) entered as within-subjects variables. The intervention timing and preferred maneuvers were analyzed using Chi-square Tests of Independence and log-linear analyses. In addition, post hoc pair-wise comparisons were performed at the .05 alpha level to aid in interpretation of the interactions.

The primary hypothesis was not supported, as there was no significant difference found between pilots' and air traffic controllers' overall risk ratings. There also was no main effect of flight condition on risk ratings. Although not hypothesized, a main effect was found for proximity, with the near-proximity scenarios rated higher in risk than the far-proximity scenarios, $F(1,60) = 23.71, p = .000$.

Role and Flight Condition Effects on Risk Ratings

Although no main effect was found for role or flight condition, pilots' and controllers' risk ratings differed based on proximity and flight condition in combination, with a significant three-way interaction for Role x Flight Condition x Proximity, $F(1, 60) = 6.307, p = 0.015$. As Table 2 shows, controllers' risk ratings for the near-proximity scenarios were significantly higher than were pilots' ratings across both flight conditions. Also, proximity affected how controllers rated risk in both flight conditions, with consistently higher ratings assigned to the near-proximity scenarios than the far-proximity scenarios. For pilots, proximity had little effect, and when it did (controlled flight) the effect was in the opposite direction to that indicated by controllers.

Table 2

Role x Flight Condition x Proximity Mean Risk Ratings

Proximity	Pilots		Controllers	
	Controlled Flight	FF	Current ATC	FF
Near	36.2	33.7	47.0	46.3
Far	42.1	33.6	31.4	35.4

A four-way interaction was found for Role x Flight Condition x Density x Vertical Profile. As shown in Table 3, controllers mean risk ratings for the high-density/descending scenarios were significantly higher than were the pilots' ratings ($p = .005$) across both flight conditions. In addition, both pilots and controllers in the controlled flight condition rated the high-density/descending scenarios significantly differently from the other three pairs of scenarios (low-density/descending, high- and low-density/level); with controllers assigning these scenarios the highest risk ratings and pilots assigning them the lowest. Controllers also rated the high-density/descending

Table 3

Role x Flight Condition x Density x Vertical Profile Mean Risk Ratings

Vertical Profile	Pilots				Controllers			
	Controlled Flight		FF		Controlled Flight		FF	
	High-density	Low-density	High-density	Low-density	High-density	Low-density	High-density	Low-density
Level	43.3	42.3	35.0	32.9	32.5	42.5	38.2	42.0
Descending	31.2	39.7	31.3	35.5	48.1	33.7	44.7	38.4

scenarios significantly higher in risk than the high-density/level scenarios in both flight conditions, as well as the low-density/descending scenarios in FF. In the controlled flight condition, controllers rated the low-density/level scenarios significantly higher in risk than the low-density/descending scenarios, but showed no difference between the low-density scenarios in the FF condition.

A four-way interaction also was found for Role x Density x Vertical Profile x Proximity, which represented a single scenario in each condition. As shown in Table 4, controllers rated the near-proximity scenarios significantly higher in risk than the far-proximity scenarios, with one exception. Controllers rated risk higher in the high-density/descending scenario with the far-proximity conflicting traffic than the high-density/descending scenario with the conflicting traffic nearer in proximity. For pilots, significant effects based on proximity were found only in the level scenarios, and the pattern was not consistent across proximity conditions. Pilots rated the low-density/level/near-proximity scenario significantly higher in risk than the low-density/level/far-proximity scenario; however, in the high-density/level scenarios they rated the far-proximity scenario higher in risk than the near-proximity scenario.

Table 4

Role x Density x Vertical Profile x Proximity Mean Risk Ratings

Proximity	Pilots				Controllers			
	High-density		Low-density		High-density		Low-density	
	Level	Descend	Level	Descend	Level	Descend	Level	Descend
Near	30.7	31.1	40.8	37.2	45.5	42.2	57.2	41.5
Far	47.6	31.4	34.4	38.0	25.2	50.6	27.2	30.5

In addition, pilots' risk ratings were also affected by traffic-density across all vertical profile and proximity conditions. The pilots rated the low-density scenarios higher in risk than the high-density scenarios in all cases except the far-proximity/level scenario. For controllers, traffic-density only affected risk ratings in the near-proximity/level scenarios (low-density scenario rated higher than high-density) and far-proximity/descending scenarios (high-density scenario rated higher than low-density).

Flight Condition Effects on Risk Rating Response Times

A main effect on risk rating response times was found for the flight condition, $F(1,60) = 7.024, p = 0.01$. Response times were shorter in the FF flight condition than in the controlled flight condition, with mean response times of 2.52 seconds and 3.05 seconds, respectively.

Again, a three-way interaction was found for Role x Flight Condition x Proximity, $F(1,60) = 6.892, p = 0.011$. For pilots in the FF condition, proximity affected mean response times, with shorter times in the far-proximity scenarios than in the near-proximity scenarios (see Table 5). Alternatively, proximity affected controllers' mean RT in the controlled flight condition, with shorter times in the far-proximity scenarios than the near-proximity scenarios. In addition, controllers responded significantly more

quickly in the FF condition than in the controlled flight condition in both the near- and far-proximity scenarios.

Table 5

Role x Flight Condition x Proximity Mean Response Times

Proximity	Pilots		Controllers	
	Controlled Flight	FF	Controlled Flight	FF
Near	2.95	2.75	3.28	2.46
Far	2.93	2.46	3.05	2.41

Role Effects on Intervention Timing

A Chi-square Test for Independence was run to determine whether controllers responded to traffic conflicts earlier in the scenarios than did pilots (see Table 6). To categorize the interventions, the picture number on which the participant intervened was divided by the total number of pictures in that scenario, then classified into early (the first third of the scenario), middle (the second third of the scenario), and end (the final third of the scenario).

Table 6

Pilot and Controller Intervention Time Within-Scenarios

Time within Scenario	Pilots			Controllers		
	Controlled Flight	FF	Total	Controlled Flight	FF	Total
Early	17	15	32	53	43	96
Middle	31	43	74	39	49	88
End	38	37	75	9	10	19
Total	86	95	181	101	102	203

A significant difference was found between pilots and controllers, $\chi^2 (2, N = 384) = 65.5, p < .005$, but no significant difference was found between flight conditions.

Controllers' interventions were more likely to occur in the early and middle portions of the scenarios, with few interventions happening at the end of the scenarios. Pilots rarely intervened in the early portions of the scenarios, but were equally likely to intervene in the middle and end portions of the scenarios. In this analysis all interventions were used, including the communicate-only and halt descent responses.

Role Effects on Preferred Conflict Avoidance Maneuvers

Although controllers intervened more often than did pilots, a Chi-square Test for Independence revealed no significant difference in the number of interventions (see Table 7). Intervention maneuvers were then analyzed to determine if the maneuvers preferred by pilots and controllers were significantly different. The climb and descend frequencies were combined into a total vertical frequency and the left and right turns were combined into a total horizontal frequency. A log-linear analysis revealed that pilots and controllers varied significantly in their preferences for the three response types. Pilots were equally likely to use the three types of maneuvers to avoid a conflict (total vertical = 46, total horizontal = 41, total combination = 40). Controllers, however, were

Table 7

Pilot and Controller Intervention Maneuver Preferences

Maneuver	Pilots			Controllers		
	Controlled Flight	FF	Total	Controlled Flight	FF	Total
Climb	15	9	24	5	7	12
Descend	11	11	22	3	6	9
Combination	14	26	40	1	1	2
Turn left	5	8	13	31	20	51
Turn right	14	14	28	29	29	58
Communicate	27	27	54	1	12	13
Halt descent	N/A	N/A	N/A	32	26	58
Total	86	95	181	102	101	203

most likely to use horizontal actions, and only occasionally used vertical maneuvers (total horizontal = 109, total vertical = 21, total combination = 2). Whereas pilots frequently used combination maneuvers (such as a climbing turn), controllers avoided these maneuvers almost completely. There was no significant effect of flight condition, as the frequency and type of responses remained stable across both flight conditions. The communicate-only and halt descent frequencies were excluded from this analysis.

A final Chi-square Test for Independence was run to determine whether pilots and controllers differed in their communication preferences. Pilots were significantly more likely than were controllers to select communicate-only as their preferred action in response to an anticipated conflict, $\chi^2(2, N = 67) = 7.71, p < .005$.

Discussion

Effects Based on Role

Although the main hypothesis anticipating a difference between roles was not supported, the pilots' and controllers' judgments of risk differed depending on specific traffic situations. Both the interactions of Role x Flight Condition x Proximity and Role x Density x Vertical Profile x Proximity indicate that in most cases controllers perceived higher risk in the near-proximity scenarios than the far-proximity scenarios. In accordance with their existing professional duties, controllers' responses indicate that maintaining legal separation was of primary importance. This finding is supported by comments made by air traffic controllers who attended a briefing on this study at NASA Ames Research Center. They stated that controllers must maintain 5 miles of separation and a failure to do so entails a professional risk (J. Holbrook, personal communication, June 13, 2001). Further support for these results is provided by the intervention timing

analysis which indicated that controllers preferred to maneuver earlier in the scenarios than did pilots, which is consistent with the strategic nature of the controllers' role, requiring them to resolve potential conflicts well before the situation approaches a LOSS.

Conversely, pilots indicated either no difference in risk related to proximity, or in some cases rated risk lower in the near-proximity scenarios. Though this result might appear counter-intuitive, comments made by pilots during debriefing offer some explanation. Many of the pilots stated that they were comfortable allowing the conflicting aircraft to get closer before making a determination as to the level of risk and the need to maneuver. Several stated that the scale of the display made it difficult to determine exactly how closely the conflicting aircraft would fly to their own aircraft, as well as to how and where it would cross their flight path. By waiting until the aircraft got closer they could make what they felt to be more accurate judgments, and avoid unnecessary maneuvers. These findings correspond to the Orasanu et al. (2001) survey results indicating that uncertainty increased decision difficulty, as well as the pilots' concern with the potential economic and productivity losses due to maneuvering.

Another finding related to role is shown by the Role x Flight Condition x Density x Vertical and Role x Density x Vertical x Proximity interactions. Regardless of flight condition and proximity, controllers rated the high-density/descending scenarios higher in risk than did the pilots, who assigned these scenarios their lowest risk ratings. This finding is supported by the controllers' preferred maneuvers. The two types of maneuvers that controllers selected least often (vertical and combination responses) both included vertical movement, which was one element of the traffic situations they rated highest in risk.

When participants indicated how they would prefer to maneuver, controllers were most likely to use horizontal actions, and only occasionally used vertical actions (see Table 7). Controllers were also likely to request vertically maneuvering aircraft to level off (an option unavailable to pilots), removing the vertical element from the traffic-separation equation. Controllers rarely used combination maneuvers, which were the actions most frequently used by pilots. Pilots were nearly equally likely to use each of the three possible maneuver types and were slightly more likely to communicate prior to taking some action than were controllers. Lozito et al. also found that pilots were equally likely to use altitude and heading to resolve conflicts (2000).

The preferred maneuver findings may be related to the experiences of the participants. Feedback from air traffic controllers who attended a briefing on this study at NASA Ames Research Center offered some explanation for the controllers' preference for horizontal maneuvers. Based on their own experiences, they proposed three reasons why controllers chose to use horizontal maneuvers in this study (J. Holbrook, personal communication, June 13, 2001):

1. Pilots complain to them if the controllers ask them to change altitude, possibly due to the extra effort required to make a vertical change as opposed to a heading change. [Though not mentioned by the controllers in the NASA briefing, pilots' complaints when asked to make vertical maneuvers may be due to a concern over increased fuel usage.]
2. Because it's easier for the pilots to execute a heading change than an altitude change, the pilots respond faster to a controller's request if they only ask them to change heading; therefore, heading changes represent the fastest way to maintain separation.

3. The controller may only "own" a certain, limited vertical range of airspace, and therefore feel constrained in terms of suggesting altitude changes.

The difference in preferred maneuvers may also be related to the environment in which the participants routinely operate. Although controllers must think and resolve conflicts in a three-dimensional environment, both the display used for this study and those used daily are two-dimensional depictions of the world. Pilots routinely operate in a three-dimensional environment, which may help explain why they were more likely to use three-dimensional maneuvers to resolve the conflicts they perceived. Though most displays currently provided to pilots also use two-dimensional presentations, pilots must physically operate in three dimensions. Pilots' maneuvers may also reflect a trade-off between efficiency and safety, as they are at physical risk in flight.

The effects of proximity and traffic density indicate that individual traffic situations have a greater effect on pilots and controllers than the flight condition, and affect the two groups differently. The scenarios that received the highest risk ratings from both pilots and controllers were examined to determine what elements led to the higher risk ratings. For pilots, the conflicting aircraft in the highest rated scenario was flying at the same altitude and in generally the same direction as the reference aircraft. With a heading about 37 degrees greater than that of the reference aircraft, it was clearly difficult to determine where the flight paths would cross. For controllers, the heading of the conflicting aircraft in the highest rated scenario was closer to 75 degrees from that of the reference aircraft. With the two aircraft converging at a nearly 90 degree angle, it was clear the two aircraft would be close, but it was still difficult to determine where the flight paths would cross. In addition, the conflicting aircraft changed course near the end

of the scenario. Although this maneuver increased separation, the uncertainty of the conflicting aircraft's intentions may have had a greater affect on the controllers than the pilots. In each case, uncertainty was a component of the scenarios, which is a known element of risk (Orasanu et al., 2001; Yates & Stone, 1992).

Another result that required further examination was the finding that controllers assigned higher risk ratings in the high-density/descending scenarios to the far-proximity scenario than the near-proximity scenario (see Table 4). This result may be explained by the relationship of the two aircraft to each other when the scenarios ended. In the near-proximity scenario, though the target aircraft was in closer proximity to the reference aircraft than the target aircraft in the far-proximity scenario on the horizontal plane, it was 600 feet below the reference aircraft and descending, so although it entailed a LOSS, it was clear that there would be no mid-air collision. When the far-proximity scenario ended, both aircraft were at the same altitude and still flying conflicting flight paths, so a mid-air collision was a possibility. This shows that although legal separation was critical to controllers, flight safety clearly was a priority. This is consistent with the excellent safety record of the airspace managed by the U.S. air traffic controllers.

Effects Based on Flight Condition

The three-way interaction of Role x Flight Condition x Proximity reflected a difference between pilots' and controllers' risk ratings based on the flight condition. The pattern of controllers' ratings was consistent across flight conditions, with near-proximity scenarios rated higher in risk than the far-proximity scenarios. In contrast, pilots differed across flight conditions, with higher risk ratings in the controlled flight condition than in the FF condition. Proximity did not affect pilots' risk ratings in the FF condition, and

far-proximity conflicts were judged only slightly more risky than near-proximity conflicts in the controlled flight condition. One reason for the effect of the flight condition on pilots' ratings may be the sense of self-control they were given in the FF condition (Johnson & Tversky, 1984). Rather than having to depend on someone else (a controller) to ensure safe separation, they themselves were responsible for it. In addition, pilots in the controlled flight condition were faced with uncertainty as to when and how a controller would be taking action to resolve a perceived conflict, which may help explain why risk ratings were higher than in the FF condition (Orasanu et al., 2001; Yates & Stone, 1992).

A second main effect was found with shorter response times in the FF condition than in the controlled flight condition, which may reflect the participants' comfort levels with the new rules. Pilots may have responded more quickly in the FF condition as a result of the increased control given them by the new rules, as they were no longer required to interpret how a controller was planning to resolve the conflict and could rate the risk immediately based on their own perception. Conversely, controllers' faster responses may be due to their decreased responsibility for separation in the FF condition. In the FF condition, the controllers could also assign risk ratings based on their own perception without the distraction of developing a strategy to resolve the conflict.

There was also a three-way interaction of Role x Flight Condition x Proximity for response times. Both pilots in the FF condition and controllers in the controlled flight condition had shorter response times in the far-proximity scenarios than in the near-proximity scenarios. These findings may reflect the need by both groups to analyze more

closely the scenarios that included closer proximity traffic in the flight condition that was under their direct control.

Conclusions

The results of this study suggest that specific traffic conditions had a greater influence on the risk perception of pilots and air traffic controllers than the operative flight environment. Some role effects were found as well, with the effect of the traffic conditions differing for pilots and controllers. The primary differences in risk ratings found between pilots and air traffic controllers were related to the proximity of the conflicting aircraft, traffic density, and vertically transitioning traffic. The only element of the study that was affected by the flight condition was response times, with shorter times in the FF condition. In addition, both pilots and controllers responded more quickly in the scenarios that included far-proximity traffic in the flight condition that was under their direct control. For both of them, slower response times to near-proximity targets may reflect greater levels of cognitive processing (analysis) in this condition.

Aircraft flying in relatively close proximity significantly increased controllers' perceptions of risk, which should be taken into consideration in developing new traffic-separation procedures. It appears likely that air traffic controllers will perceive increased risk if separation standards are decreased. For pilots in this study, it appeared that the effect of proximity on risk ratings was related to uncertainty when aircraft were at a greater distance, which is consistent with findings in the Remington et al. (2000) study showing that longer time to a conflict increased median response times. This is relevant to the development of conflict detection technology, the design of cockpit displays of traffic information, and the consideration of pilot self-separation standards. The higher

risk ratings given by controllers to the descending traffic scenarios, along with their avoidance of vertical separation maneuvers, suggests that controllers may be more comfortable with, or just more experienced with, two-dimensional traffic separation than are pilots. This information is pertinent not only to the design of traffic displays and separation standards, but also to ensuring that both groups are knowledgeable regarding the others' most likely responses in a traffic conflict. Such knowledge may help avoid increased perception of risk as changes to the air traffic control system are implemented, especially if pilot self-separation is an element of such changes.

There is strong evidence that pilots and controllers prefer to use different methods to resolve conflicts and that the two groups take action at different times. Controllers consistently acted earlier in the scenarios than did pilots, which likely relates to their strategic role in air traffic management and the need to maintain the flow of traffic. Pilots, on the other hand, tended to act in a more tactical manner, waiting until the conflicting traffic was closer to their aircraft. This accomplished two goals: limiting or preventing unnecessary maneuvers and avoiding extra fuel usage due to those maneuvers. These findings have significance for the development of conflict resolution procedures, especially to accomplish the goal of avoiding an increase in risk perception as a result of modifying the air traffic management system.

Ongoing studies seek to identify the optimum displays and the quality of information needed to allow pilots to accomplish safe self-separation in a free flight environment. It is clear from the results of this study that continued research is needed to integrate the human element with technological advances if the NAS system is to retain the excellent safety record enjoyed to date.

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Appendix A

Proposal approval form

Human Subjects Review Board approval form

San José State
UNIVERSITY

**Office of the Academic
Vice President**

**Associate Vice President
Graduate Studies and Research**

One Washington Square
San Jose, CA 95192-0025
Voice: 408-924-2480
Fax: 408-924-2477
E-mail: gstudies@wahoo.sjsu.edu
<http://www.sjsu.edu>

TO: Jeannie Davison
1212 Oakland Road, #142
San Jose, CA 95112

FROM: Serena W. Stanford *Serena W. Stanford*
AAVP, Graduate Studies & Research

DATE: June 20, 1997

The Human Subjects-Institutional Review Board has approved your request to use human subjects in the study entitled:

**"Differences in Risk Perception Between
Pilots and Air Traffic Controllers"**

This approval is contingent upon the subjects participating in your research project being appropriately protected from risk. This includes the protection of the anonymity of the subjects' identity when they participate in your research project, and with regard to any and all data that may be collected from the subjects. The Board's approval includes continued monitoring of your research by the Board to assure that the subjects are being adequately and properly protected from such risks. If at any time a subject becomes injured or complains of injury, you must notify Serena Stanford, Ph.D., immediately. Injury includes but is not limited to bodily harm, psychological trauma and release of potentially damaging personal information.

Please also be advised that all subjects need to be fully informed and aware that their participation in your research project is voluntary, and that he or she may withdraw from the project at any time. Further, a subject's participation, refusal to participate, or withdrawal will not affect any services the subject is receiving or will receive at the institution in which the research is being conducted.

If you have any questions, please contact me at (408) 924-2480.

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<http://www.sjsu.edu>

To: Jeannie Davison
1212 Oakland Road, #142
San Jose, CA 95112

From: Serena W. Stanford *Serena W. Stanford*
AVP, Graduate Studies & Research

Date: July 29, 1998

This letter acknowledges that the Human Subjects-Institutional Review Board has received the request for extension of the following proposed study entitled:

**"Differences in Risk Perception Between Pilots
and Air Traffic Controllers"**

Since there are no major changes to the protocol, the Human Subjects-Institutional Review Board has granted this project a one year extension effective from the date of this letter.

If you have any questions, please do not hesitate to contact me at (408) 924-2480.

San José State
UNIVERSITY

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Vice President**

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<http://www.sjsu.edu>

To: Jeannie Davison
1212 Oakland Road, #142
San Jose, CA 95112

From: Nabil Ibrahim
Acting AVP, Graduate Studies & Research

Date: June 30, 1999

This letter acknowledges that the Human Subjects-Institutional Review Board has received the request for extension of the following proposed study entitled:

**"Differences in Risk Perception Between
Pilots and Air Traffic Controllers"**

Since there are no major changes to the protocol, the Human Subjects-Institutional Review Board has granted this project a one year extension effective from the date of this letter.

If you have any questions, please do not hesitate to contact me at (408) 924-2480.