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IDENTIFICATION OF IMPORTANT "PARTY LINE" INFORMATIONAL ELEMENTS AND THE IMPLICATIONS FOR SITUATIONAL AWARENESS IN THE DATALINK ENVIRONMENT

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7 May 1992

ASL-92-2

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ABSTRACT

Air/ground digital datalink communications are an integral component of the FAA's Air Traffic Control (ATC) modernization strategy. With the introduction of datalink into the ATC system, there is concern over the potential loss of situational awareness by flight crews due to the reduction in the "party line" information available to the pilot. "Party line" information is gleaned by flight crews overhearing communications between ATC and other aircraft. In the datalink environment, party line information may not be available due to the use of discrete addressing. Information concerning the importance, availability, and accuracy of party line elements was explored through an opinion survey of active air carrier flight crews. The survey identified numerous important party line elements. These elements were scripted into a full-mission flight simulation. The flight simulation experiment examined the utilization of party line information by studying subject responses to the specific information elements. Some party line elements perceived as important were effectively utilized by flight crews in the simulated operational environment. However, other party line elements stimulated little or no increase in situational awareness. The ability to assimilate and use party line information appeared to be dependent on workload, time availability, and the tactical/strategic nature of the situations. In addition, the results of both the survey and the simulation indicated that the importance of party line information appeared to be greatest for operations near or on the airport. This indicates that caution must be exercised when implementing datalink communications in these high workload, tactical sectors.

This document is based on the thesis of Alan H. Midkiff submitted in partial fulfillment of the degree of Master of Science in Aeronautics and Astronautics at the Massachusetts Institute of Technology.

Acknowledgments

This work was supported by National Aeronautics and Space Administration/Ames Research Center and the Federal Aviation Administration under grant NAG 2-716.

The authors would like to acknowledge the following persons for their contributions to this study:

- American Airlines Manager of Flight - Central Carl Price for his support during the survey phase of the research and AA ATC Coordinator Roy Harmon for his assistance in the procurement of the ATC communications recordings. Also a special thanks to AA Manager - Operations Systems Planning Paul Ryan for his overall support of the project and for insight into current datalink issues.

- The local and national representation of the Allied Pilots Association.

- Dave Gross of USAir Express for distribution of the preliminary pilot surveys.

- Sandy Lozito, Sherry Chappell, and Alison McGann of NASA-Ames for their guidance, assistance and hospitality during all phases of the research, especially the aspects requiring expertise in aviation psychology.

- Elliot Smith, Dave Pepitone, Mike Smiley, and Barry Sullivan of the NASA-Ames Man-Vehicle System Research Facility for their contribution to the design and execution of the simulation experiment.

- The professional pilots who took time away from their busy schedules to participate in both the survey and the simulation experiment.

CONTENTS

1. Introduction

Every day thousands of general aviation and scheduled air carrier operations utilize the services of the current Air Traffic Control (ATC) and airway flight service system. Much of this airspace is operating near capacity levels and, in many terminal areas, at or beyond full capacity. Air/ground communications are currently handled via VHF radio voice communications between the aircraft and various ATC facilities. There are significant limitations of the voice system as indicated by the high number of Aviation Safety and Reporting System (ASRS) submissions identifying breakdowns and saturation in VHF voice channels. For example, of the more than 14,000 ASRS reports received in 1985 and 1986, one fourth involved problems in air/ground information transfer [1].

As part of the Federal Aviation Administration's (FAA) National Airspace System modernization plan, digital datalink communications will be introduced as a means of air/ground information exchange between aircraft and ATC facilities. Communications via datalink offer potential benefits in increased system safety and efficiency. These would be achieved by reducing transmission and interpretation errors and by allowing more information to be exchanged between aircraft and ground facilities. On the other hand, the transfer of ATC communications from voice to datalink gives rise to numerous human factors issues including a possible loss of flight crew situational awareness. Specifically, the discrete nature of datalink addressing (where an ATC message is directed exclusively to a specific aircraft) may result in a loss of indirect or "party line" information (PLI). Crewmembers obtain PLI through frequency monitoring by overhearing communications between ATC and other aircraft. The identification of important PLI elements is necessary to form a basis by which compensatory datalink protocols or strategies can be developed.

This report documents efforts to identify party line information elements currently available in the ATC system and to determine their relative importance. Importance of PLI was addressed through an opinion survey of active airline pilots which also explored the accuracy, and availability of numerous PLI elements. The most important PLI elements were further investigated in a flight simulation study where crew responses to specific information elements could be tested.

The results are presented as follows. Chapter 2 outlines the primary motivation for this work, including a discussion of digital datalink development and potential PLI-datalink tradeoffs. Chapter 3 describes the design and results of the pilot opinion survey on the importance, accuracy, and availability of PLI information elements. Chapter 4 details the flight simulation study of PLI usage. A summary of the conclusions is contained in Chapter 5.

2. Background

The development of the air/ground communication system has paralleled the commercial development of civil aviation. The ATC system has had to accommodate both increases in air traffic and operating restrictions which result from congestion and noise considerations. As the system has become more saturated, the need to move to alternate forms of communication has increased. Alternate communication forms, such as datalink, must be evaluated for possible adverse effects as well as advantages, since their implementation may result in eliminating benefits such as indirect information sources. An example of such an indirect source is the Party Line Information (PLI) found in current voice communications.

2.1. Party Line Information (PLI)

In the current ATC environment, voice communications are made on a common VHF frequency where aircraft, tuned to that particular frequency, can monitor all of the transmissions. Some of this "party line" information is used by pilots to increase their situational awareness with respect to other aircraft and/or environmental conditions. An example of this type of information is turbulence and ride reports. Aircraft along a similar route or altitude often convey turbulence information to controllers that other aircraft can overhear. Party line information is also useful for assessing sector congestion and controller workload. It has other indirect uses such as providing flight crews with the frequent psychological assurance that they are in contact with ATC, i.e. their communications equipment is still functioning normally. Voice inflection by controllers and pilots can also indicate the urgency of an instruction or situation. Controllers will often solicit PLI by requesting information from other aircraft such as enroute ride reports, airspeed gain or loss on final approach, and braking action reports on landing roll-out. Intentional PLI is also utilized in the transoceanic environment where pilots maintain a listening watch on dedicated VHF air-to-air frequencies and also on the universal emergency (guard) frequency, 121.5 MHz.

PLI is available to aircraft any time pilots are monitoring a common frequency. However, the reliability of PLI is not assured. PLI is available only part time since there is no certainty that an aircraft which might need the information is tuned to the appropriate frequency. Additionally, if the crew is in a high workload situation, they may not have the spare cognitive capacity to monitor PLI communications. Another party line issue is the danger of constructing a mental picture of a situation based on incorrect assumptions. However, based on cockpit observations, most pilots appear to use PLI only as a *supplemental* information source and rarely make important decisions predicated on PLI alone.

An analysis of ATC communications in the Chicago terminal area (Appendix A), indicated that PLI with *potentially* useful information was present in approximately 90% of arrival transmissions. It should be noted, however, that these results are biased towards high PLI content since the criteria for *potential* PLI in the analysis included any transmission containing PLI regardless of its importance or context. The PLI content relevant to a particular aircraft is normally only a small fraction of the total PLI available on the frequency. The fraction of communications that contained potential PLI did not appear to vary significantly with different weather conditions or arrival traffic congestion in the areas observed.

2.2. Air/Ground Digital Datalink Development

2.2.1. VHF Voice Communications

Currently, air/ground communications between ATC and flight crews are carried out almost exclusively by voice radio transmissions that contain all clearance, advisory, and warning information. A formalized communication protocol exists between pilots and controllers which works reasonably well, however, even strict adherence to these procedures does not guarantee successful message comprehension.

Despite the considerable efforts that have gone into developing current ATC communications procedures, significant problems inherent to oral information exchange remain. These problems consist of both human and system factors. Human factor elements include substandard radio technique and clearance retention problems. For example, retention difficulties can occur when controllers attempt to economize "air-time" by issuing rapid and complex multi-parameter verbal instructions that can tax pilot's short term memory resulting in erroneous clearance interpretation. System factors include frequency congestion problems and simultaneous transmissions which result in the frequent blocking of transmissions requiring message repetition, or worse, the acknowledgment of a message by the wrong receiver. This creates two problems for the

ATC system to resolve. Discrete aircraft addressing using a digital datalink can reduce problems of overlapping transmissions on congested channels. The storage of the digital information in on-board computers will allow review of complex instructions thereby reducing clearance interpretation problems.

2.2.2. ACARS

Air carriers have been utilizing air/ground datalink communications for many years to efficiently exchange company information such as departure and arrival times. The ACARS (ARINC Communications Addressing and Reporting System) system is operated by ARINC (Aeronautical Radio Incorporated), a firm set up by several airlines that specializes in providing communications between airline operations and aircraft by using a network of landlines, phone patch relays, and/or datalink. The ACARS unit is a terminal located in the cockpit with which information can be manually downlinked by crewmembers. In some cases, specific information elements (such as engine performance data) can be automatically downlinked. ACARS currently uses dedicated VHF channels. Messages, such as destination weather or arrival gate information, can also be uplinked from the ground and routed to an onboard printer. Information exchange can be initiated by the flight crew, the airline's operations, or automatically.

2.2.3. ACARS Pre-Departure Clearance and FMC Programming

Recent ACARS developments include the ability to receive Pre-departure ATC Clearances (PDC) and accomplish on-board Flight Management Computer (FMC) programming during preflight planning prior to boarding the aircraft. The PDC program began on a trial basis at Chicago O'Hare, San Francisco, and Dallas-Fort Worth, and after demonstrating favorable operational effectiveness, is now available at most major U.S. airports. To initiate a PDC, the crew requests their ATC clearance via ACARS and confirms acceptance, at many airports, by reading back the transponder code (a unique code assigned to each flight for positive radar identification) upon initial contact with ground control. Clearance confirmation procedures vary among airports.

The Flight Management Computers (FMC) aboard modern "glass cockpit" aircraft require a significant amount of pre-flight programming of the waypoints that define the proposed route of flight in addition to critical performance information. For several airlines, FMC programming via the ACARS datalink can be initiated by the flight crew by typing a simple code into any company computer terminal. The entire proposed route of flight, winds aloft, takeoff speeds, and performance data can be batch transmitted to the aircraft's on board FMC via the ACARS unit, saving as much as 25 to 30 minutes of pre-flight programming (in the case of extended transoceanic flights), and reducing pilot input errors.

2.2.4. Datalink and the National Airspace System Plan

In the proposed ATC datalink system, digital messages will be electronically transferred to visual displays or printers located in aircraft cockpits. Other modalities such as synthesized voice are also being evaluated [2]. The system may incorporate a broad range of VHF channels, including HF, satellite and Mode S. It should be noted that, the National Airspace System plan does not call for 100% datalink communications. Voice communications will always be available as a backup in the foreseeable future. The full extent of what information will be communicated digitally has yet to be determined [3].

In the oceanic environment, satellite systems will support digital communications replacing the antiquated HF voice reporting system currently in use. In the near future, the Oceanic Display and Automation Processing System at the oceanic control centers in Oakland and New York will be enhanced by automatic FMC position reports (Automatic Dependent Surveillance, ADS) downlinked to FAA facilities via a satellite datalink. The expected increases in reliability and accuracy over the current HF system may allow a relaxation of the conservative separation standards now in use. This will enable the system to accommodate greater numbers of simultaneous transoceanic flights and provide more flexibility in flight level and route selection [3].

Mode S datalink communications are slated to provide relief to congested terminal operations. In addition to ATC surveillance and tracking capabilities of the current Mode C system, Mode S acts as a modem for two-way digitally coded data exchange between the ground and the aircraft for ATC purposes. The transponder also passes data between aircraft for collision avoidance purposes (TCAS, traffic collision avoidance system). The Mode S system is expected to serve as the FAA's primary domestic datalink for the delivery of ATC and flight advisory services [3].

Potential uses for an ATC datalink system include transmitting alphanumeric route amendment messages to aircraft, and the possibility of automatically loading route modifications directly into onboard FMC's (in a manner similar to ACARS pre-flight programming). The flight crew would, of course, retain the authority to accept or reject the modified route. Automatic FMC loading would allow the crew to obtain a graphical depiction of the proposed amendment and then execute/comply with the clearance within a reasonable amount of time. This would help to increase safety margins by reducing the amount of "heads down" time crews spend reprogramming during busy phases of flight thereby allowing them to spend more time exercising the "traffic watch" required to maintain adequate separation from other aircraft.

2.3. PLI and Datalink Issues and Tradeoffs

In the datalink environment, the availability of PLI will be reduced due to the discrete nature of datalink addressing where an aircraft only receives messages intended solely for it. Some voice communications will still be present since not all aircraft will be equipped with datalink, and datalink-equipped aircraft may from time to time require voice transmissions depending on need or established procedures. For the most part, however, datalink will provide for a quiet flight deck environment where crewmembers will not need to constantly screen the background chatter for useful information. Although pilots learn to filter out unrelated information while engaged in other activities, some cognitive resources are employed to screen the incoming data and flag the crewmember's attention when needed [4].

The results of past research indicate that many pilots are concerned with the potential reduction of PLI [2,5,6,7,8,9]. Many international pilots draw parallels to the loss of situational awareness experienced when operating at foreign destinations where the background communications are in an unfamiliar language. The value of PLI must be balanced against the detrimental aspects of having to filter large amounts of verbal data in order to obtain useful information. In the absence of any form of compensation, it would appear that the intrinsic benefits of datalink -- accuracy, lack of congestion, automatic FMC programming, etc. -- are only possible at the expense of a reduction in the available PLI. It is therefore necessary to identify important party line elements so protocols and strategies for retention and/or compensation can be developed.

In order to maintain the benefits of PLI but reduce the negative impact on situational awareness, care must be taken in designing datalink protocols. Previous attempts at compensatory strategies designed to augment situational awareness include CDTI (Cockpit

Display of Traffic Information - a predecessor to TCAS [10]) and proximity addressing, where messages are datalinked to aircraft within a specific radius of one another. Unfortunately both these schemes increased the crew workload and heads down time as flight crew members were required to screen data to determine relevancy [9].

2.4. Research Focus

The specific focus of this research has been to attempt to determine the significance of PLI to air carrier crews in the current ATC environment in order to provide a baseline from which decisions on datalink implementation can be made. Certain elements of party line information may contribute significantly to pilot situational awareness and consideration should be given to means of preserving the most useful information in the datalink environment. Specific issues which were addressed include:

- Identification of important party line information elements.
- Determination of the utility of party line information in the current environment.

An understanding of the amount of utilization of important party line elements should provide a basis for preservation strategies to maintain the benefits of PLI in the datalink environment. Preservation by specified procedures and/or compensation technologies require the knowledge of *which* elements are used and *how* they are used by pilots. In order to investigate these issues, user input was solicited through pilot opinion surveys. The survey results were then used to design a full-mission flight simulation experiment which studied how important elements were used in cockpit decision making of air carrier flight crews.

3. Pilot Opinion Survey

3.1. Objectives

In order to assess the overall usage of PLI in the current ATC environment, specific input from the users was solicited through a pilot opinion survey. The survey was limited to active transport category crews in order to focus on the most frequent users of high density airspaces that ATC services. The goal of the survey was to obtain subjective user data in the following areas:

- Assessment of the *importance* of PLI in the current ATC environment.

- Assessment of the *accuracy* of PLI in the current ATC environment.

- Assessment of the *availability* of PLI in the current ATC environment.

- Subjective opinions concerning datalink:
    • User preference of datalink/PLI environment with and without compensation.
    • User assessment of effectiveness of TCAS as PLI compensation.
    • User opinions on possible PLI compensation strategies.

Flight crew input on the importance, accuracy, and availability of PLI was solicited for information specific to certain phases of flight to determine the variation of PLI significance among different flight regimes. Pilot input concerning general information that is independent of phase of flight was also solicited.

3.2. Survey Design

The survey was organized in three sections. The first section studied the importance, availability, and accuracy of specific party line information elements as a function of phase of flight. The second section focused on general items and information valid across all phases of flight. In both of these sections, pilots were presented with individual PLI elements to be scored with incremental rating scales in terms of importance, availability, and accuracy. In the third section, pilots were asked for their opinions on various datalink implementation issues. This section also contained an area for free comments.

3.2.1. Section I - Phase of Flight Specific PLI

The first section of the survey solicited pilot input on party line importance, availability, and accuracy across six phases of flight from pre-departure to final approach. An example of the format of the survey depicting the rating scales for the Departure phase is shown in Figure 3.1.

PHASE OF FLIGHT	IMPORTANCE	AVAILABILITY	ACCURACY
	trivial — critical	non-existent — common-place	unreliable — reliable
Departure: *takeoff to top of climb*			
next comm freq	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
weather situation	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
ride reports/turbulence	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
traffic watch	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
controller errors	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
other______________	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5

Figure 3.1 Survey Sample

The survey presented potential PLI elements so that each element could be ranked for the Importance, Availability, and Accuracy of the information. This format allowed the subjects to consider the different aspects of each element simultaneously. The general organization of the survey presented these elements according to phase of flight since certain elements are found only in specific phases, and significance may vary across phases. The subjects were asked to rank each item for importance, availability, and accuracy on the 5 point scales defined in Figure 3.1.

In order to present the pilots with appropriate PLI elements for consideration, a list of potentially important party line information elements was constructed. The full list of the PLI elements included in the first section of the survey is presented below in Table 3.1. The list was developed from a preliminary survey distributed to 40 air carrier pilots. The preliminary survey offered various PLI elements which the subjects were asked to rank by significance. Those initial elements were selected based on a strawman list of candidate PLI elements drawn up by several aviators experienced in air carrier, general aviation, and military operations. In addition to information on PLI significance, data from the 14 respondents to the initial survey included comments on survey design, question format, and additional PLI information elements. These results were used in producing the final version of the survey. The final survey is included in Appendix B. A brief explanation of the information elements is presented in Table 3.2.

Ground Operations: *dispatch, pre-start, taxi*
- Next Comm Freq
- Routing to Runway
- Ground Sequencing
- Taxi "Hold Short" Instructions for Other A/C
- A/C Crossing Active Runway While You Are Lined Up for Takeoff
- Controller Errors

Departure: *takeoff to top of climb*
- Next Comm Freq
- Weather Situation (including deviations)
- Ride Reports/Turbulence
- Traffic Watch
- Controller Errors

Cruise: *top of climb to top of descent*
- Next Comm Freq
- Weather Situation (including deviations)
- Ride Reports/Turbulence
- Winds Aloft
- Traffic Watch
- Sequencing
- Controller Errors

Descent: *top of descent to approach control contact*
- Next Comm Freq
- Weather Situation (including deviations)
- Ride Reports/Turbulence
- Traffic Watch
- Sequencing
- Holding Situations/EFC Validity
- Controller Errors

Terminal Area: *approach control contact to final approach fix*
- Next Comm Freq
- Weather Situation (including deviations)
- Ride reports/turbulence
- Traffic Watch
- Sequencing
- Holding Situations/EFC Validity
- Terminal Routing/Runway Assignments
- Approach Clearance
- Controller Errors

Final Approach: *final approach fix to runway threshold*
- Next Comm Freq
- Weather Situation (minimums)
- Traffic Watch
- Sequencing
- Missed Approach - weather induced
- Missed Approach - other
- Windshear
- Aircraft on Your Landing Runway
- Braking Action
- Taxiway Turnoff

Table 3.1 PLI Categories by Phase of Flight

Next Comm Freq = Next communication frequency to be used, i.e. next controlling sector.

Routing to Runway = Sequence of taxiways to follow in order to arrive at runway.

Ground Sequencing = Sequential order of aircraft on the ground.

Taxi "Hold Short" Instructions for Other A/C = Instructions to other aircraft from ground control to give way to ownship.

A/C Crossing Active Runway While You Are Lined Up for Takeoff = Other aircraft cleared by tower to cross the active runway downfield while ownship is holding in position lined up on the same runway awaiting takeoff clearance.

Controller Errors = Erroneous information and/or instructions issued by air traffic control.

Weather Situation = Terminal or enroute weather conditions which may result in deviations.

Ride Reports/Turbulence = Reports by other aircraft of presence of inflight turbulence.

Traffic Watch = Out-of-the-window vigilance for the purpose of maintaining safe inflight separation from other aircraft.

Winds Aloft = Wind direction and speed at a given altitude.

Sequencing = Sequential order of inflight aircraft, usually along a common course.

Holding Situation/EFC Validity = Determination of number of other holding aircraft and the anticipated departure time from the holding pattern.

Terminal Routing/Runway Assignments = Flight course as aircraft approaches destination airport, including active runway for landing.

Approach Clearance = Clearance from ATC to begin executing published approach procedure currently in use for a given runway.

Missed Approach - Weather Induced = Balked landing because of weather below minimums resulting in the inability to visually acquire the runway environment.

Missed Approach - other = Balked landing for reason other than weather, e.g. traffic on runway, etc.

Windshear = Sudden change in direction or speed of wind which may result in the deterioration of flight conditions.

Aircraft on Your Landing Runway = Previous arrival unable to clear runway of intended landing resulting in the loss of safe separation.

Braking Action = Aircraft braking ability as effected by contaminated runway surfaces (snow, ice, standing water, etc.).

Taxiway Turnoff = Taxiway to be used to exit runway after landing rollout.

Table 3.2 Explanation of Party Line Information Elements

3.2.2. Section II - General PLI

The second section of the survey addressed numerous party line items which were not related to a specific phase of flight. This section also addressed information that is not directly related to aircraft operation but may be used by pilots for overall situational awareness. The general elements were ranked for importance, availability, and accuracy using the same rating scales as Section I. The elements contained in Section II of the survey are listed below in Table 3.3. The first four elements are related to prosodic information which is indirect information transmitted by voice inflection or phraseology.

- *Controller's experience level inferred from tone of voice and speech patterns.*
- *Pilot's (of other aircraft) experience level inferred from tone of voice and speech patterns.*
- *Controller's "level of urgency" inferred from tone of voice and speech patterns.*
- *Pilot's (of other aircraft) "level of urgency" inferred from tone of voice and speech patterns*
- *Sector congestion (as indicated by frequency congestion).*
- *Background ATC transmissions used as reassurance of being "in contact" with the controller ("Anybody out there?").*
- *Call sign confusion (other aircraft accepting your clearance or vice versa).*
- *ATC facilities and problems/lost communications.*
- *Navaid facilities and problems.*

Table 3.3 Non-Phase Specific Party Line Survey Items

3.2.3. Section III - Implementation Issues

In the third section of the survey, pilots were given the opportunity to express their views on a potential datalink communications environment and to offer suggestions on the effectiveness of possible party line preservation schemes. The first two questions contained rating scales where pilots could record their degree of preference for a datalink environment, with and without provisions for the compensation of party line information. This was done to assess the perceived value of PLI compensation. These were followed by a question addressing the use of TCAS as an alternate means for enhancing situational awareness. The specific wording of these questions is presented with the results in Section 3.3. Pilot's comments concerning compensation or PLI in general were explicitly solicited.

A background section was also included to acquire data about the pilot's flight experience, equipment flown, type of training, familiarity with EFIS (Electronic Flight Instrumentation System) equipment, and personal computer use.

3.3. Survey Results

The survey was distributed to 1500 Chicago O'Hare-based American Airlines flight crewmembers. Authorization was obtained from both American Airlines management and the local Allied Pilots Association (APA) representation to place the surveys in the individual pilot mailboxes at the company's operations center. Responses were collected in a box located in the same room. All respondents were guaranteed individual anonymity and the surveys were kept confidential. A total of 184 surveys were recovered, most of which were returned within two months of initial distribution. The response rate of 12% was considered normal for a voluntary survey of this type, particularly due its extensive nature. However, because the respondents were self-selected, the data may not be fully representative of the pilot community at large.

The survey results are presented below as mean ratings for each PLI element since the variance did not change significantly for most cases. However, the complete numerical results along with standard deviation data are available in Appendix C. A 95% confidence interval analysis on the mean response ratings is shown in Appendix D.

3.3.1. Section I: Importance Ratings

The mean value of importance for each element from Section I is depicted in Figure 3.2. The perceived overall importance of the surveyed PLI elements is indicated in the figure by the high mean scores. All but three items scored greater than the midpoint score of 3.0. In addition, there is some variation among specific individual elements as a function of flight. For example, traffic watch and controller errors scored lower in cruise as compared to departure and terminal area. These items, which contain information used in aircraft flight path management, tend to be more time critical in dynamic phases of flight such as departure or terminal area operations. In contrast, PLI involving strategic information such as ride reports, which rated higher in cruise than in climbout or descent, appears to be more important in less dynamic flight regimes. The importance for each phase of flight as a group is examined in detail in Figure 3.5 later in this section. From an overall view of the data, it is apparent that those items concerned with the terminal area and final approach phases tend to be higher in importance than the other phases.

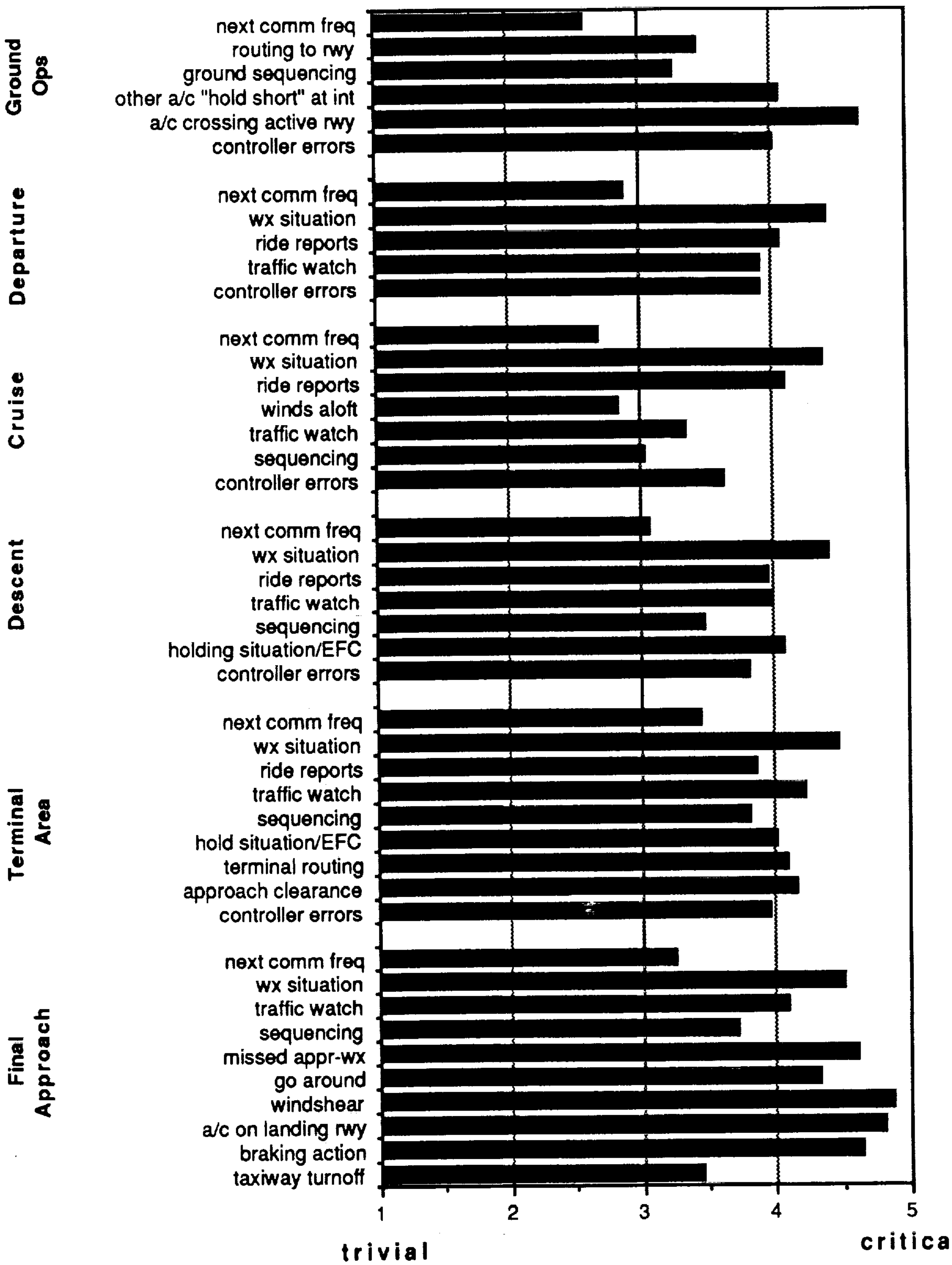

Figure 3.2 Importance of PLI, All Elements

As seen in Figure 3.2, the perceived importance of a given party line information element varied among different phases of flight. To obtain an integrated picture of the importance of topical groupings of party line information, the scores of related elements in different phases of flight were averaged. The mean importance of the related groups of PLI (across all phases of flight) are shown in Figure 3.3.

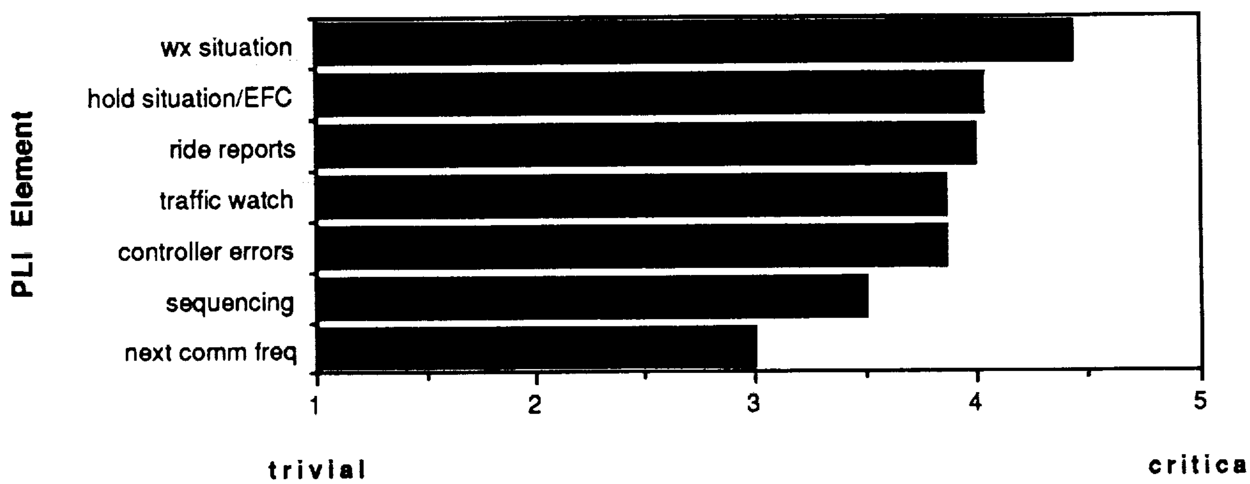

Figure 3.3 Importance of Related Groups of PLI Integrated Across Phases of Flight

From Figure 3.3 it is clear that PLI containing weather information was perceived as most important. This category was comprised of both enroute weather and terminal windshear. Holding situation and ride report information scored 2nd and 3rd at similar importance levels. These top three items contain information used in strategic planning. This observation was supported by the following pilot comments:

> *"I have personally used such info to avoid potentially hazardous weather and other situations including clearances given in error where such info caused me to question a clearance relative to what was going on around us."*

> *"A pilot needs to have a 'feel' for how the system is flowing toward his destination. Weather, deviations, rides, holding and EFC's for others are important for a pilot so he can 'look' ahead."*

Traffic watch and controller errors contain information typically used for tactical planning and, although important, scored slightly less than the strategic elements. The next communication frequency appeared to be more of a convenience item than an important information element as indicated by the neutral importance score of 3.0.

In order to focus on the elements perceived as most important, the 10 highest scoring PLI elements or related groups are presented in rank order in Figure 3.4. All elements or groups in Figure 3.4 scored above 4.0 in importance.

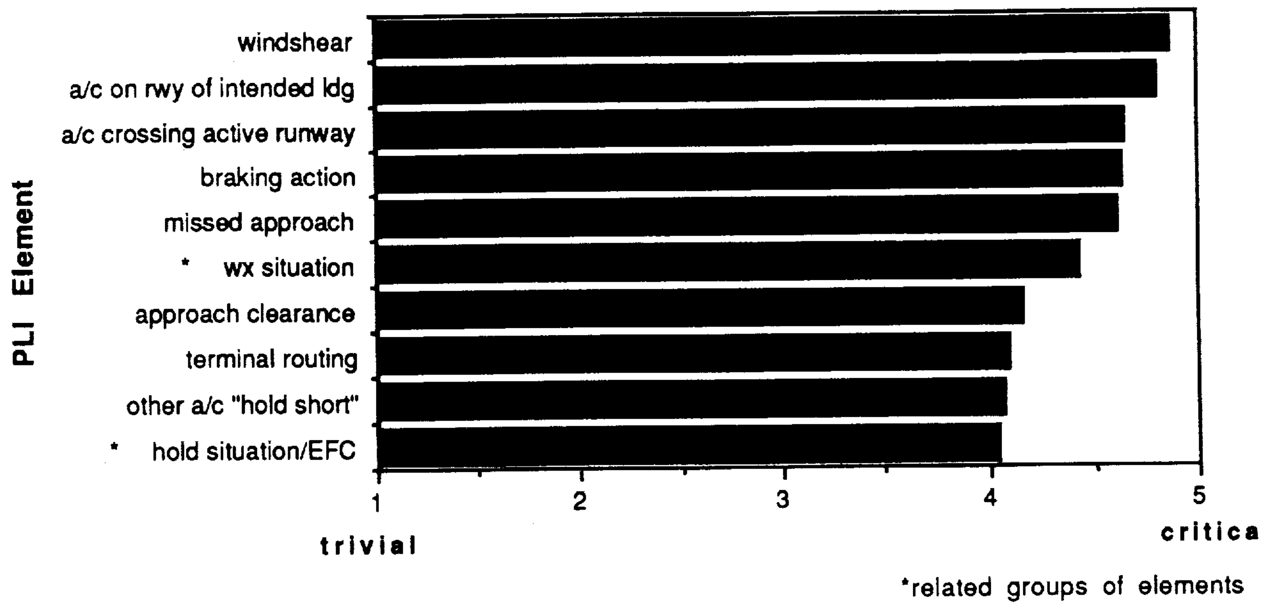

Figure 3.4 Importance of Specific PLI Elements

As can be seen, the top five elements are all "runway" or "near-runway" events. Windshear on final approach ranked the highest in perceived importance. This is consistent with similar findings in other studies that indicate pilot reports are perceived to be the most accurate or reliable source of windshear information [11].

The second and third elements in importance were the presence of an aircraft on the runway of intended landing and an aircraft crossing the active runway. It should be noted that an aircraft on the runway of intended landing was a major factor in an accident which occurred at Los Angeles (LAX) on 1 February 1991. Since this occurred during the same time frame that the survey was distributed, it may have influenced the perceived importance of this element.

The other runway related elements, braking action and missed approach information, ranked 4th and 5th in importance. Windshear, braking action, and missed approach information vary quickly in time and are important to flight operations. Pilots endeavor to prepare for these conditions by actions such as approach reference speed adjustments, abandoning the approach in the presence of windshear, or selecting a more appropriate auto-brake setting during poor braking conditions.

Terminal routing and approach clearance information ranked 6th and 7th in importance, scoring just above the 4.0 level. Both of these items occur in the high workload environment near the destination airport. Terminal routing usually culminates in the approach clearance from which point pilots fly the published approach procedure to landing. Early indications of the expected routing or approach allow pilots to set up the applicable navigation systems or program the FMC before entering the busy terminal area where these tasks would require undesirable "heads down" time .

It is important to note that all of the top scoring items are associated either with an aircraft's approach or landing. These phases are typically the most time critical phase of flight. The time critical nature of arrival activities (including minimizing "heads down" time in order to provide for an adequate traffic watch) and the high importance attributed to party line information in the terminal area, suggest that, from a PLI standpoint, approach and tower control frequencies are less desirable candidates for initial datalink implementation than other "enroute" operations.

In order to investigate the relative importance for different phases of flight, the mean score across all items within a given phase was tabulated in Figure 3.5.

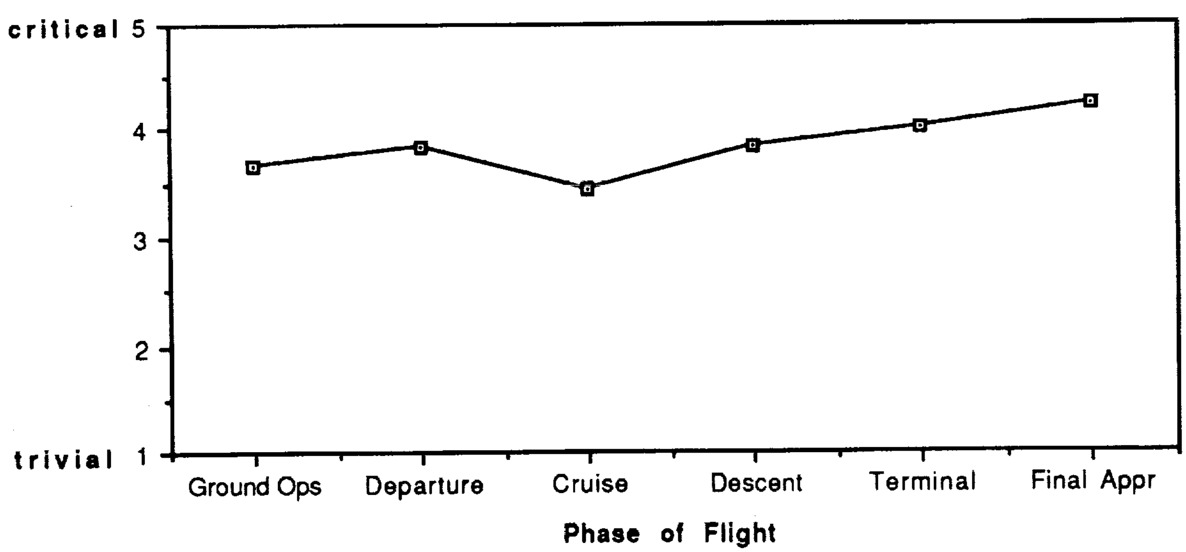

Figure 3.5 Importance of PLI by Phase of Flight

As noted above, there appears to be a weak trend for the perceived importance of PLI to increase with proximity to the airport. While this may not be statistically significant, this observation was also supported in the general comment section of the survey:

> *"The need for PLI varies inversely with distance from a congested terminal area. Pilots subconsciously train themselves to filter out unneeded PLI. Data-linked PLI will all be presented with the same priority and be more difficult to filter, thereby compounding the problem when need is greatest."*

> *"Many times PLI is misleading - next freq doesn't apply to us or ride report doesn't apply to our area...PLI becomes more critical the closer one gets to the field; there almost all info applies to us - holding, next freq, speeds, expected runways, go-arounds, runway conditions..."*

In addition, the phases of flight where course and altitude adjustments are frequent, such as departure, terminal area, and final approach, generally scored higher than ground operations or cruise.

3.3.2. Section I: Accuracy Ratings

The results from the accuracy ratings of the survey concerned the perceived reliability of party line information to pilots. The mean reliability values for each element are depicted in Figure 3.6.

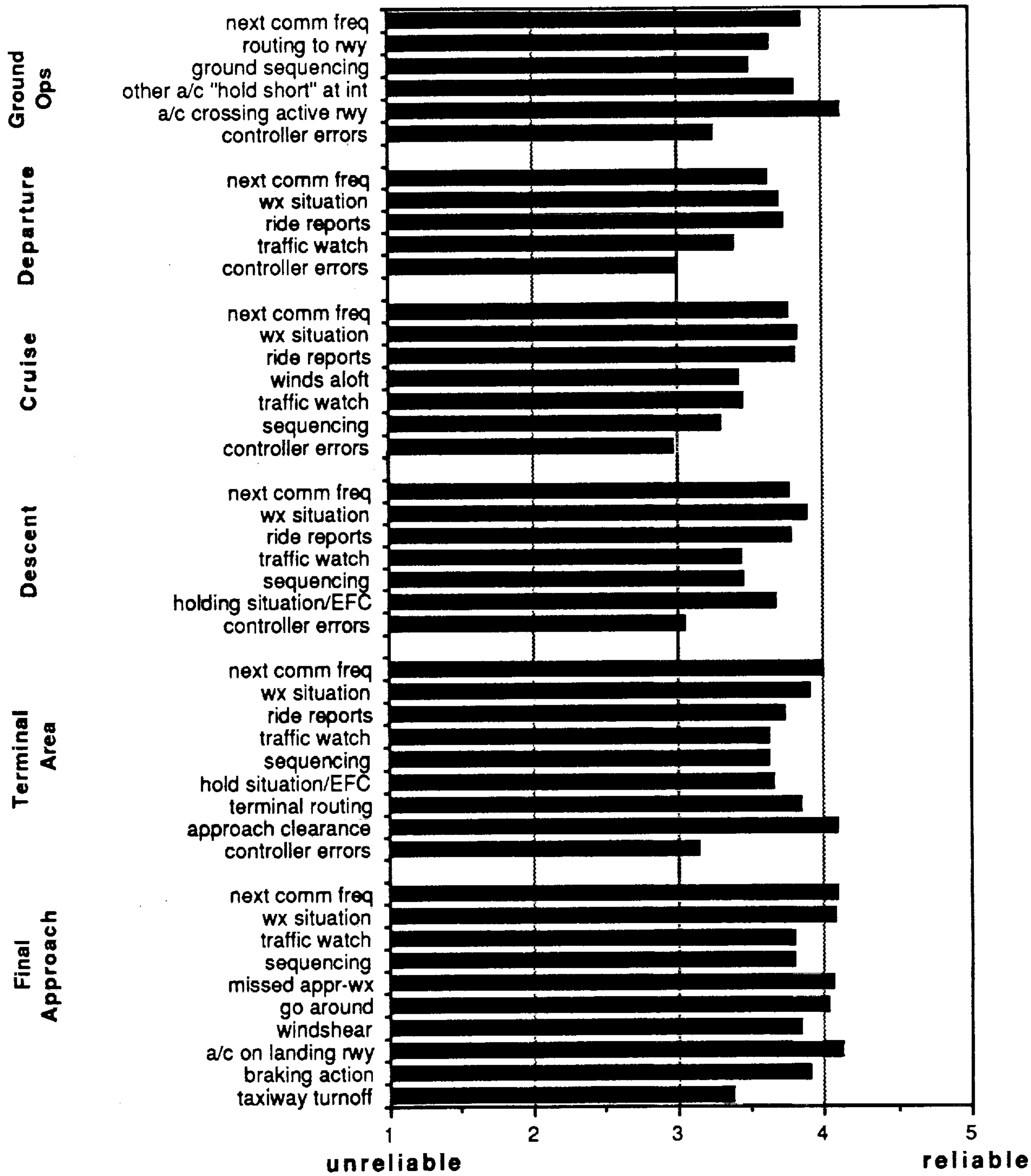

Figure 3.6 **Accuracy of PLI, All Elements**

As can be seen in Figure 3.6, the accuracy means did not change significantly between different phases of flight. The overall accuracy mean was 3.66 which indicates that the reliability was perceived to be moderately high. An exception was controller errors which had noticeably lower reliability scores. Also, the accuracy of the individual elements did not change significantly for each phase of flight. Controller errors consistently scored low in terms of reliability among all phases which indicates pilots do not have confidence that controller errors can be reliably detected from party line information. The highest scoring PLI elements from Figure 3.6 indicate that the runway incursion items, aircraft crossing the active runway and aircraft on runway of intended landing, were considered the most reliable, followed by approach and missed approach items.

The ratings of each similar element in different phases of flight were averaged to obtain a picture of the reliability of topical PLI groupings. Category groupings of party line accuracy integrated across all phases of flight are depicted below in Figure 3.7

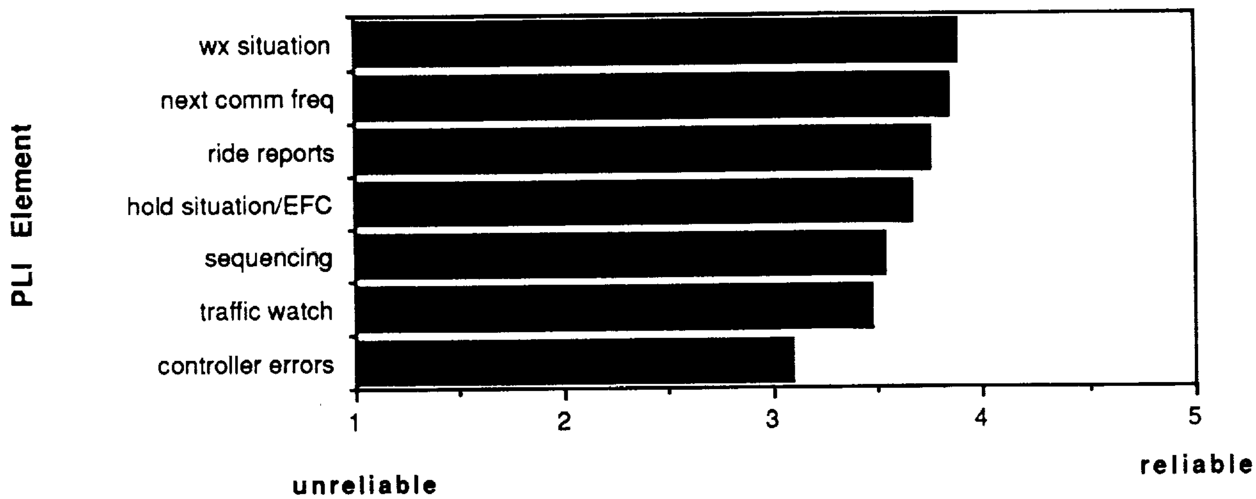

Figure 3.7 Accuracy of PLI Categories Integrated Across Phases of Flight

Among the topical groupings in Figure 3.7, the low score for the reliability of detecting controller errors is the most significant. Party line information as a means of detecting controller errors is perceived as important (3.9/5.0) by pilots but not very reliable (3.1/5.0).

Weather situation information scored as most reliable. This is consistent with the weather "importance" scores and also supports the finding that weather related reports from other pilots (PIREPS) are perceived to be highly reliable.

3.3.3. Section I: Availability Ratings

The results of the availability ratings from the survey are shown in Figure 3.8 and indicate the perceived availability of PLI. Note that the survey addressed the perceived availability of PLI elements ranging from nonexistent to commonplace. Pilots may perceive information to be highly available, even if it is infrequent as long as it is available when needed. For example, holding situation information was perceived to be moderately available, 3.8/5.0, even though it is infrequent, because the information is commonly available in those situations when holding is occurring.

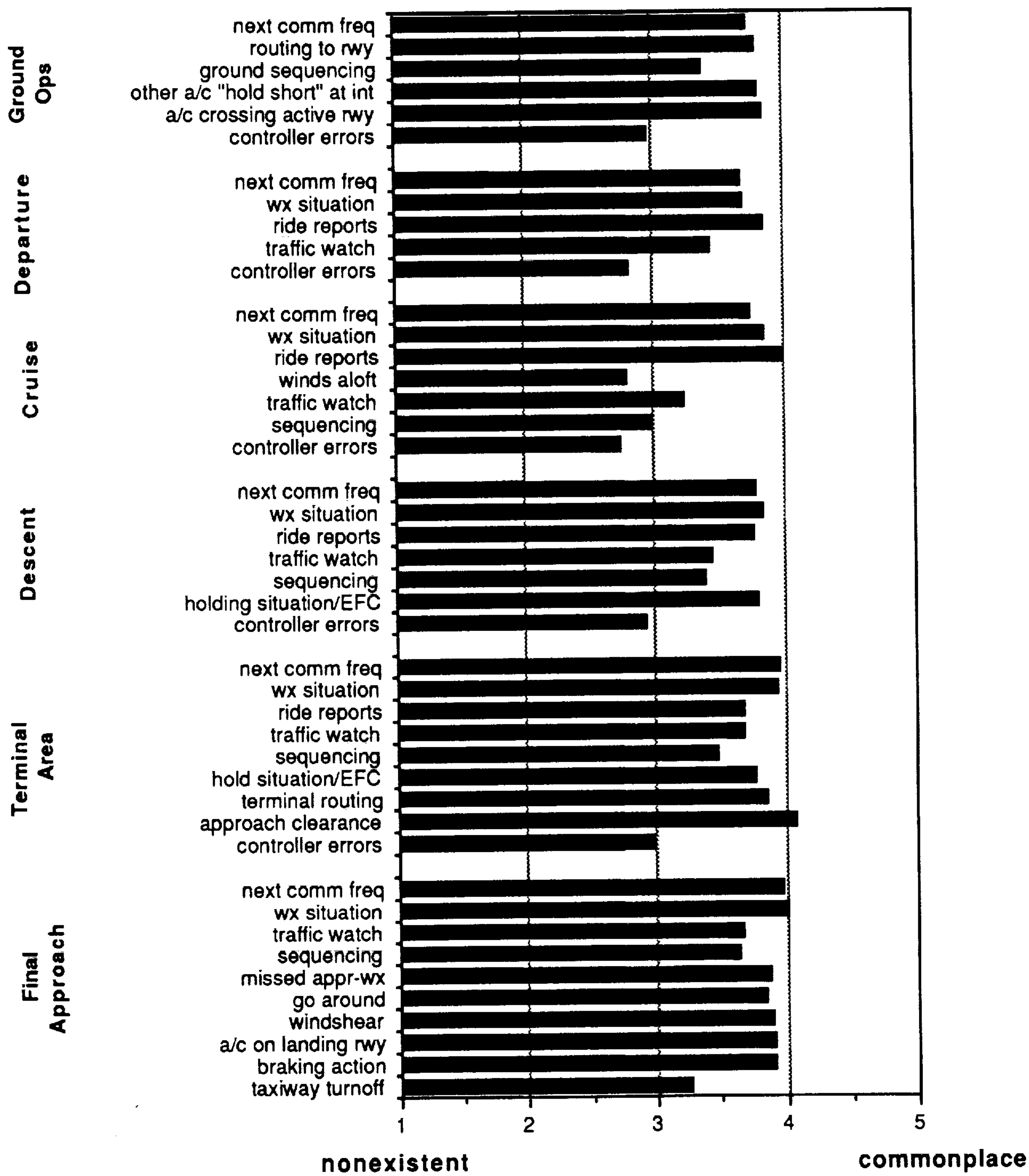

Figure 3.8 Availability of PLI, All Elements

The overall availability did not change significantly between different phases of flight, although from Figure 3.8, it can be seen that the final approach items tended to rate a somewhat higher availability than in cruise. Also, the availability of specific items such as traffic watch and sequencing increased during the descent and terminal area phases. This is consistent with the tendency for traffic density to increase as approaching aircraft converge on a destination. The overall availability mean over all phases was 3.56 indicating most items rated as moderately available. The exception was controller errors which had the lowest availabilities for each phase of flight. In addition, the low availability of items such as winds aloft in cruise suggest that these elements are good candidates for PLI compensation.

Specific types of PLI elements were again grouped into the related categories integrated across all phases of flight and ranked by availability. The results are depicted in Figure 3.9.

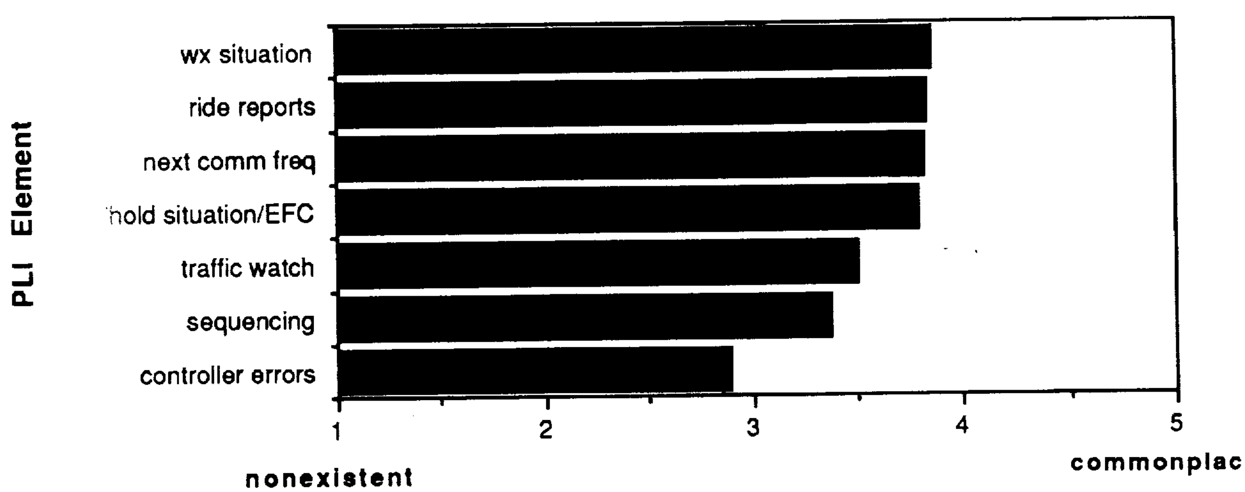

Figure 3.9 Availability of General PLI Categories

The categories of weather situation, ride reports, next communication frequency, and hold situation/EFC were considered the most available. In addition to being issued in a standardized format, the information contained in all of these items is relatively easy for pilots to apply (or extrapolate) to their own flight situations. Weather situation and ride reports are commonly requested by crews, therefore much of this information is available to all listening on the frequency. Next communication frequencies are issued at high frequency in a standard format and are repeated to each aircraft passing out of the sector in a specific direction. Holding situation procedures, while less frequent, also require a standard and complete communication protocol including specific entry information and expected further clearance times which are easy to interpret.

Traffic advisories and sequencing vectors, which rated slightly lower than the top four, are routinely given to flight crews by ATC, especially during departure and arrival. However, in order to interpret the PLI, these elements require an understanding of the tactical situation which might not always be available. Controller errors cumulatively scored the lowest due in part to the unpredictability of these occurrences and the difficulty in identifying errors from PLI alone.

3.3.4. Section II: General PLI Elements

The importance ratings from PLI elements in Section II which are not directly related to specific phases of flight are shown in rank order in Figure 3.10.

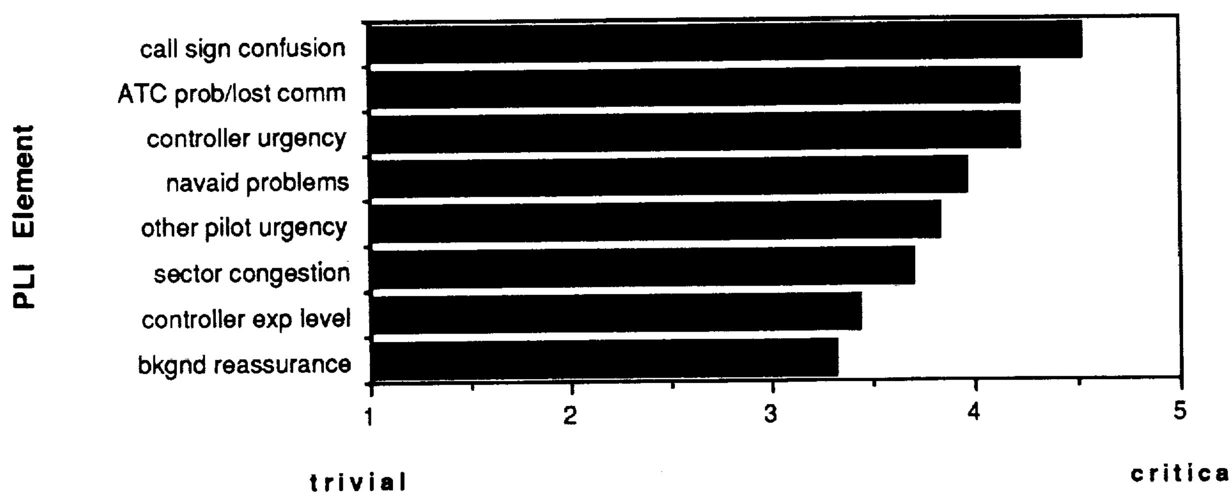

Figure 3.10 Importance of Miscellaneous PLI Elements

Call sign confusion was perceived as the most important general PLI element. However, call sign confusion is expected to be alleviated in the datalink environment by the inherent nature of discrete datalink addressing. ATC problems/lost communications were also perceived as important. It should be noted, however, that the survey responses were likely to have been influenced by a major power outage at Chicago O'Hare (which caused widespread arrival problems) during the period the survey was distributed. Controller urgency ranked third in importance (first in importance among the prosodic elements), and had the highest perceived reliability in the accuracy rating. Controllers typically issue instructions in a calm, professional demeanor and any deviation from this, either by voice inflexion or phraseology, is likely to be indicative of a critical situation. Background reassurance ranked relatively low but was still considered somewhat important as indicated by an above neutral score of 3.31.

3.3.5. Section III: Compensation Issues

Flight crew input concerning the PLI/Datalink tradeoff and possible compensation strategies was addressed in Section III. Preferences for a datalink or PLI environment were explored by the following questions:

Considering the advantages of datalink (i.e. quiet frequency, discrete aircraft addressing, frequency congestion relief, unambiguous clearances, etc.) and of party line information (situational/environmental awareness, traffic/ride information, etc.), would you tend to support a datalink environment or the current environment containing party line information (PLI)?

Choose one:

1	2	3	4	5
DATALINK ONLY		EQUAL DISTRIBUTION VOICE / DATALINK		VHF VOICE COMMUNICATION ONLY (PLI)

- -

If some mechanism could be developed to datalink critical PLI to the aircraft (e.g.. a status display with current wx, sequencing, and/or holding information), would you tend to support a datalink environment or the present PLI environment?

Choose one:

1	2	3	4	5
DATALINK ONLY		EQUAL DISTRIBUTION VOICE / DATALINK		VHF VOICE COMMUNICATION ONLY (PLI)

The mean result for the first question was 3.03 with a standard deviation of 0.82, indicating a preference for equal distribution of voice and datalink, i.e. the mixed environment. When the question was reiterated with the qualification that PLI compensation would be accomplished by some means of datalinking critical PLI to the cockpit, the mean and standard deviation were 2.71 and 0.92 respectively. The average "shift" towards datalink (by a single respondent) was 0.50. These results indicate pilots appear to be more receptive to the use of datalink if consideration for the use of compensation is given.

Finally, the TCAS qualified pilots were asked the following question concerning the use of TCAS as a compensation system for situational awareness:

Are you TCAS qualified? _____YES _____NO If so, please comment on the effectiveness of TCAS as a compensational device for situational awareness, sequencing, and traffic watch in the datalink environment.

The answers to the questions were categorized as follows:

Favorable:	44
Neutral:	45
Unfavorable:	24

While most of the comments were neutral or somewhat favorable, the large spread of opinion can be seen in the following related comments:

<u>Favorable</u>

> *"I have noticed myself watching the TCAS in the terminal environment to obtain sequencing information. The only drawback is that as another aircraft vertically separates from you (too high or too low) you lose him, and the information."*

<u>Neutral</u>

> *"[TCAS] Should <u>never</u> be used as a substitute for situational awareness. Rather, an enhancement to it."*

<u>Unfavorable</u>

> *"No comparison. TCAS has far too many targets when in the most critical phase of flight - the terminal area. I personally get a far better situational 'picture' by listening and being active in 'the loop' to ATC. I also find TCAS to be a diversion to the highest degree possible. We are too often looking at the TCAS display instead of out the window!"*

4. Full-Mission Flight Simulation Experimental Study

4.1. Objectives

The results of the pilot opinion survey in Chapter 3 indicated that many party line elements are perceived as important by active flight crewmembers. In order to study the usage of party line information during normal flight operations, a full-mission flight simulation experiment was developed. Specific PLI elements with testable responses were scripted into the background ATC voice communications. This experiment occurred during voice communication flights which were the control phase of a "datalink" experiment conducted in the NASA-Ames Man-Vehicle Simulation Research Facility (MVSRF). Crewmember responses to each test element were evaluated in terms of level of awareness and action taken. The experiment was constructed with the following objectives.

- Examine the effectiveness of PLI elements perceived as important in the survey responses.

- Study the assimilation of PLI by examining pilot awareness of scripted PLI events.

- Study the usage of PLI by examining pilot action responses to scripted PLI events.

4.1.1. Approach

The experimental approach was to examine PLI utilization in a high fidelity full-mission simulation that presented party line elements in an operational context. The simulation examined questions involving PLI element utilization including whether or not the PLI perceived as important in the survey data could be readily assimilated by the flight crew. If assimilated, the study also examined how effectively the information was used.

Specific PLI elements which rated highly in terms of importance in the survey were scripted into a high resolution ATC voice background scenario in a way that would yield testable responses. After a training session, qualified air carrier crews were exposed to the scripted PLI in a normal operational environment during simulator data runs. The responses to the PLI stimulus in each event were observed and analyzed in terms of level of awareness and action taken.

4.2. Simulation Facility

The full-mission flight simulation was conducted in the Man-Vehicle System Research Facility (MVSRF) at the NASA-Ames Research Center, Moffet Field, CA. A major requirement of the simulation study was the ability to reproduce pilot-controller dialogue in a high resolution ATC background. The party line elements were scripted into the ATC background to study any indications of increased flight crew situational awareness and/or responses stimulated by the PLI elements. In order to allow for full voice interaction between the subject crews, ATC, and other aircraft, the components of the facility consisted of a flight simulator cab and an ATC simulation laboratory. In addition to providing standard Air Traffic Control functions, the ATC simulation lab could generate realistic communications with other background or "pseudo"-aircraft. The interface between the advanced cab, ATC, and the pseudo-pilots is depicted in Figure 4.1.

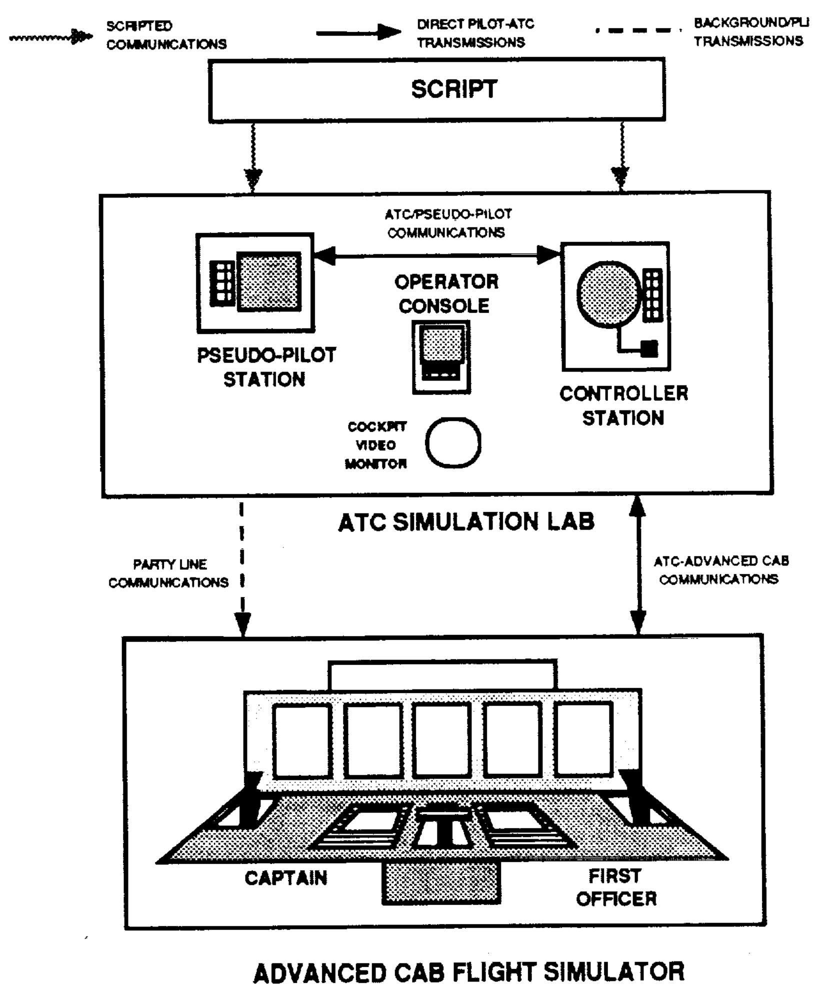

Figure 4.1 Advanced Cab - ATC - Pseudo Pilot Interface

4.2.1. Advanced Concepts Flight Simulator

The Advanced Concepts Flight Simulator (ACFS), or "advanced cab", is a full-motion base, six-axis flight simulator with size and performance characteristics similar to the twin engine B757. The cockpit interior layout (Figure 4.3) is similar to modern 2-man EFIS/FMC-equipped aircraft. A sidestick at each pilot station is used for flight control input instead of the yoke which is used on most aircraft. Engine, throttle, wing flaps, and landing gear controls are all in typical locations (accessible to both pilots), as are the other switches such as the seat belt sign and radio control panels. The Mode Control Panel (MCP), through which flight crews control autopilot functions, is identical to the one used on B757/B767 aircraft in both operation and cockpit location. The Flight Management Computer (FMC), similar to those used in navigation and performance operations in current transport aircraft, is accessed through two standard Control Display Unit (CDU) interfaces located just above the center console.

Cockpit instrumentation is presented on ten multi-function displays distributed over five vertically oriented CRT's located in front of the pilot stations. The multi-function displays on each CRT are depicted in Figure 4.2.

CRT #1	CRT #2	CRT #3	CRT #4	CRT #5
Flight Navigation	Engine/ Systems Status Datalink, Approach Charts	Advisory, Caution, and Warning Messages	Electronic Checklists/ Functional Systems	Flight Navigation

Figure 4.2 ACFS Multi-Function Displays

The CRT's accommodate "touch screen" input which is the primary interface mode for most systems selection and operation. The electronic Attitude Director Indicator (ADI) and Electronic Horizontal Situation Indicator (EHSI) "moving map", usually presented on the outermost CRTs (the CRT displays are interchangeable), are functionally identical to most Electronic Flight Instruments (EFIS) currently in use. Similarly, the engine/systems status and the advisory, caution, and warning messages are also typical of that available on current aircraft. Datalink, electronic approach charts, electronic checklists, and the operation of aircraft systems by touch screen input, however, do not have widespread use in current aircraft operations. The utilization of such equipment necessitated specialized training for the subject flight crews.

Figure 4.3 Advanced Cab Cockpit Interior

In general, the advanced cab flight and instrumentation systems were able to reproduce most aircraft operations with acceptable realism during the experiment. One notable flight instrument limitation was the inability to display simulated weather radar returns. Since it was desirable to explore the utilization of weather related party line information, a scenario approach that did not rely on weather radar had to be developed. Another limitation was imposed by the Flight Management Computer, which was a new addition to the advanced cab and had only recently become operational. This resulted in some simulator down time to work out implementation problems. An additional FMC limitation was the inability to perform automatic holding patterns due to the lack of a "holding page" on the Control Display Unit (CDU). Because holding functions are commonly available in FMCs, holding scenarios had to be preceded by an FMC failure which forced the crew to perform the hold manually.

The advanced cab is equipped with a full motion base that can simulate varying levels of turbulence, including wind gusts. Windshear models of varying intensity can be situated at different locations near several airports in the simulation database. For the purpose of this experiment, however, the windshear model was limited to a 15 knot airspeed loss due to technical difficulties in implementing the motion-base windshear dynamics at an airport whose database wind field was not originally programmed to accommodate windshear.

The simulator Phase II visual capability has been described by Chappel and Sexton as follows: [12]

> The outside visual scene is a dusk/night, full color, computer generated simulation. Visual databases include several veridical cities/airports and generic en route databases. Both light points and surfaces are projected; buildings, pavement and terrain are modeled. Two other aircraft can be flown within the field of view, a Boeing 727 and a light twin. Ground vehicles also may be seen moving about the airport. Visibility ranges from 0 to 40 miles. Flight can be conducted below, through and above multiple cloud layers of varying density. The visibility and cloud conditions can be pre-set in the flight scenario or varied during the flight from the experimenter/observer stations.

4.2.2. ATC Simulation Lab

The Air Traffic Control (ATC) Simulator subsystem of the MVSRF is a hardware/software complex which provides the MVSRF with the capability of simulating the multi-aircraft, multi-ATC position environment that is required to perform high fidelity, dynamic, and real-time full mission flight simulations.

The ATC simulation system is capable of:

1) Simulating up to four air traffic control positions, with any combination of clearance delivery, ground control, tower, approach control, and low or high center enroute sectors. In addition, ATIS can be broadcast for the appropriate database airports.

2) Generating a total of 100 aircraft (referred to as "pseudo-aircraft"), in any configuration necessary as the experiment requires. These pseudo aircraft are "controlled" at four stations directly opposite of each ATC position.

3) Allowing for the generation of two "visual" or out-of-the-window targets, which can be used to create specific traffic conflicts as the experimental situation requires.

4) Communication with an audio distribution subsystem that allows for multi-channel voice disguising between the ATC positions and/or the pseudo-pilot positions, and the advanced cab. This subsystem allows for discrete frequency assignment for each ATC sector, i.e.: if the pilot in the cab is not tuned to the correct assigned frequency, no communication between the pilot and the assigned ATC sector will exist.

As depicted in Figure 4.1, a "controller" performed the ATC duties prescribed by a script, using the voice disguiser when the aircraft transitioned between sectors. Another technician manned the pseudo-pilot station and also utilized the voice disguisers to provide the required scripted party line transmissions generated by the other aircraft in the simulation. A third technician acted as a liaison between the controller and pseudo-pilot stations. This technician also monitored a cockpit-view video monitor and resolved any technical (ATC) or logistical problems that were encountered during the simulation.

4.2.3. *Experimenter/Observer Station*

A description of the Experimenter/Observer Station as overviewed by Chappell and Sexton is presented below [12].

> The experimenter controls the simulator through the use of the Experimenter/Observer Stations located either in the cockpit or the Experimenter's Laboratory. The flight can be fully automated so that real-time intervention is not necessary. This allows each crew to experience the same sequence of events at the same time or at the same point in their flight. For example, when the aircraft has been flying for 20 minutes or reaches 10,000 feet, turbulence at a pre-defined level can be induced. The experimenter may also wish to control the occurrence of events at the time of the flight. This can be accomplished by selecting an item from an experiment scenario at the desired moment.
>
> Data collection is also controlled from the Experimenter/Observer Station. The specific parameters and the frequency of collection can be tailored for the phase of flight. Both discrete events (switch positions, etc.) and continuos variables (altitude, airspeed, etc.) are collected as a function of experiment time. In addition, all communications within the cockpit and between pilots and controllers can be recorded and time-tagged.

The Experimenter station also acted as the "company" for the purposes of radio communications involving dispatch and maintenance information during the flight simulation.

4.2.4. *MVSRF Implementation*

Subjects for the experimental study were selected from a volunteer pool of current air carrier crews, qualified on autoflight B737-300, B757, and B767 EFIS aircraft. Although it was assumed that crews familiar with these aircraft would have the least difficulty transitioning to the "advanced cab" procedures, there may have been effects due to the differences between the ACFS and the aircraft that the crews were qualified on. Minor differences in FMC procedures and unfamiliar equipment such as the sidestick controller and automated electronic checklist, may create a level of workload not normally present in certain flight regimes.

The preparation for each flight leg commenced with a briefing during which the dispatch paperwork was issued. To maintain a high level of simulation fidelity, the actual dispatch paperwork format from the subject's airline was used. The simulation was initiated prior to engine start and taxi, and terminated when the aircraft was parked at the gate. During the flight, normal ATC procedures and communications were provided by the controllers in the ATC station. Realistic background communications, including the required information for each PLI event, was provided by ATC and the pseudo-pilots.

4.3. Experimental Design

4.3.1. Method

The simulation experiment was designed to examine the usage of PLI during typical flight operations. To achieve this, candidate PLI elements were selected from those scoring highly in importance on the survey discussed in Chapter 3. Only those PLI elements with specific testable responses were selected for inclusion into the simulation scenarios. For example, weather situation ranked highest in importance among related groups of party line elements (across all phases). Therefore a turbulence related PLI weather event was scripted into the scenario. This was accomplished by having an aircraft ahead of the subject report turbulence. Crew responses were observed to see if any course deviations or other actions (such as turning on the seat belt sign, etc.) were made as a result of the PLI stimulus. The party line experiment was part of a larger study of datalink implementation. PLI response data was primarily taken during control runs where voice communications were used and PLI was available. However, some datalink only conditions were also used to compare flight path responses with and without PLI available for several test events.

4.3.2. Scenarios

Party line events were chosen for inclusion in the experiment based on the survey results from Chapter 3. All items that rated above 4.0 in importance were considered, however, only those that could reasonably be included in the simulation were selected. For example, since weather radar was unavailable in the advanced cab, no precipitation-based weather deviation scenarios could be realistically implemented. The nine PLI events that were included in the simulation are listed in Table 4.1 along with their corresponding importance rank from the survey.

Party Line Event	Category	Importance Survey Rank
PL1	Aircraft holding short at taxiway intersection	7
PL2	Aircraft crossing active runway while subject is lined up for takeoff	3
PL3	Turbulence and weather deviations	4
PL4	Aircraft on runway of intended landing	2
PL5	Holding EFC validity	6
PL6	Traffic watch while holding	5
PL7	Traffic watch during climb	5
PL8	Aircraft sequencing	8
PL9	Windshear on final approach*	1

*this event incorporates two reinforcing party line elements: windshear and missed approach

Table 4.1 Experimental Party Line Event Descriptions

Each PLI event from Table 4.1 was scripted into the simulation. The script was developed by a research group consisting of pilots, simulator engineers, and NASA-Ames psychologists. It is presented in entirety in Appendix E. The scripted PLI elements are briefly summarized below.

PL1 Aircraft holding short at taxiway intersection

Subject is on a taxiway approaching an intersection with another taxiway. Another aircraft visible to the subject crew is approaching same intersection with instructions by ATC to "hold short". The intruding aircraft does not acknowledge ATC and continues with no apparent intention to stop and give way.

PL2 Aircraft crossing active runway while subject is lined up for takeoff

Subject is in position on the active runway waiting for takeoff clearance (in low visibility conditions). A crossing aircraft approaching the active runway acknowledges a hold short instruction. Subject is then cleared for takeoff. Shortly after the takeoff roll begins, the tower clears the other aircraft to cross the active runway downfield of subject.

PL3 Turbulence and weather deviations

Subject is nearing top of climb in trail of other aircraft. Preceding aircraft report turbulence along subject's course line at the altitude that subject is climbing to.

PL4 Aircraft on runway of intended landing

Subject is "Cleared to land, number 2" behind traffic on short final in low overcast weather conditions. Dialogue between the tower and previous landing aircraft concerns vacating active runway. The previous aircraft is unfamiliar with airport and unable to clear the runway in a timely manner. As subject breaks out of the overcast, he or she encounters traffic on the runway requiring a go-around (either self-initiated or as instructed by the tower).

PL5 Holding EFC validity

Subject is in a holding pattern after executing a missed approach. Transmissions on VHF communications channel reveal other aircraft are still executing the missed approach and subsequently reporting entering holding patterns above the subject. Other aircraft in hold (below) are receiving revised EFC's (Expect Further Clearance times) that, if projected to subject, would result in an unacceptable hold time due to a minimum fuel situation. If subject does not recognize the problem, they are contacted by dispatch.

PL6 Traffic watch while holding

Subject is holding at 9000' MSL. A "pop-up" VFR light aircraft checks in at 9500' and is informed by ATC that, on its current course, it will "violate holding airspace" which would involve the subject. The VFR traffic's radio phraseology reveals "inexperience".

PL7 Traffic watch during climb

Subject is climbing out on departure. ATC issues traffic advisory (referring to subject) to crossing aircraft above and ahead of subject. The crossing aircraft responds "no contact" to repeated advisories and the situation deteriorates to a near miss.

PL8 Aircraft sequencing

Subject is in the middle of a line of aircraft being vectored around a rectangular pattern (downwind, base, final) All aircraft are given near identical speed, heading, and altitude instructions (both in front of and behind subject). The controller erroneously neglects to turn subject from downwind to base, but does call for the aircraft in sequence directly behind subject to turn. If subject does not detect the missed turn, then the controller continues to vector the subject to the final approach course.

PL9 Windshear on final approach

Subject is on final approach and the previous aircraft on approach reports large airspeed deviations due to windshear, with one of them going around. The subject encounters an airspeed loss at 900 feet above the ground that may require a go-around.

The party line events discussed in Table 4.1 were scripted into a 3-leg simulation sequence shown in Figure 4.4:

Flight Leg	PLI Elements
LAX-SFO (diversion to SMF)	PL1 - Aircraft holding short at taxiway intersection PL2 - Aircraft crossing active runway PL3 - Turbulence and weather deviations PL4 - Aircraft on runway of intended landing (resulting in a go-around at SFO, holding, and diversion to SMF) PL5 - Holding EFC validity PL6 - Traffic watch while holding
SMF-SFO	PL7 - Traffic watch during climbout
SFO-LAX	PL8 - Aircraft sequencing PL9 - Windshear on final approach

Note:
LAX = Los Angeles
SMF = Sacramento
SFO = San Francisco

Figure 4.4 Party Line Event Distribution

The flight profiles are presented in Figures 4.5, 4.6, and 4.7. Each scripted party line event is labeled (PL1, PL2, etc.) at the appropriate locations on the profiles.

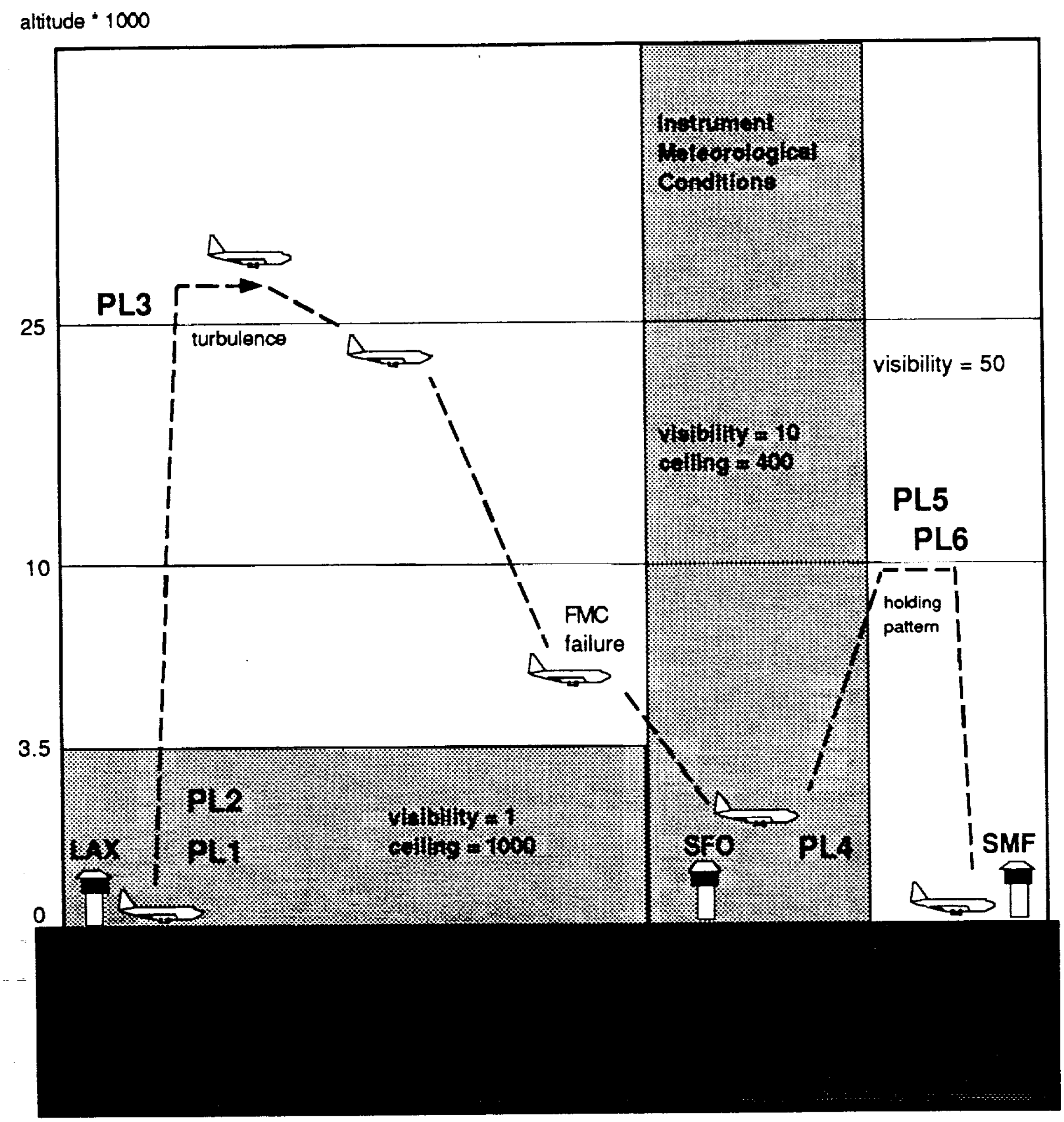

Figure 4.5 PLI Simulation Flight Profile - LEG 1

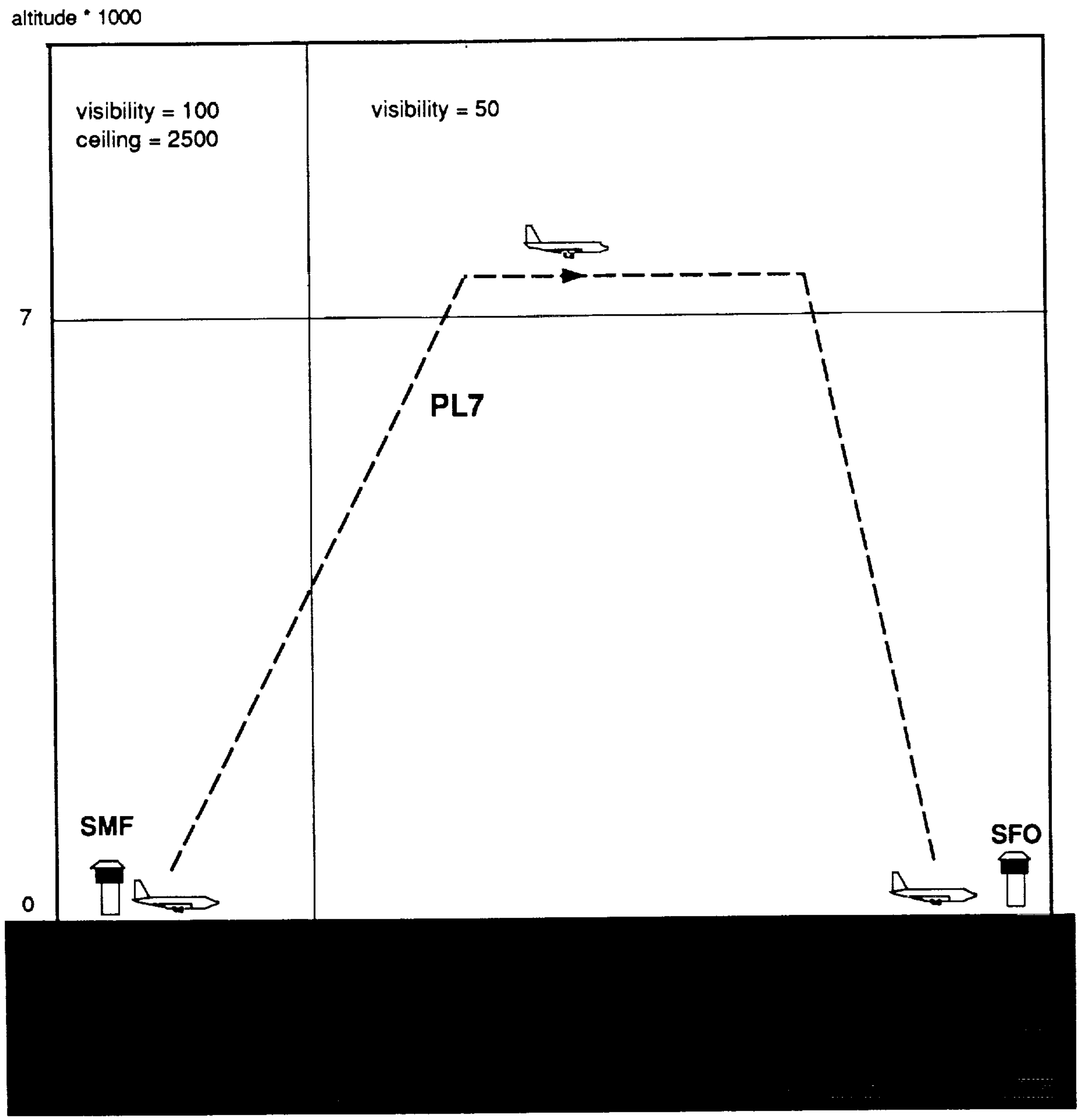

Figure 4.6 PLI Simulation Flight Profile - LEG 2

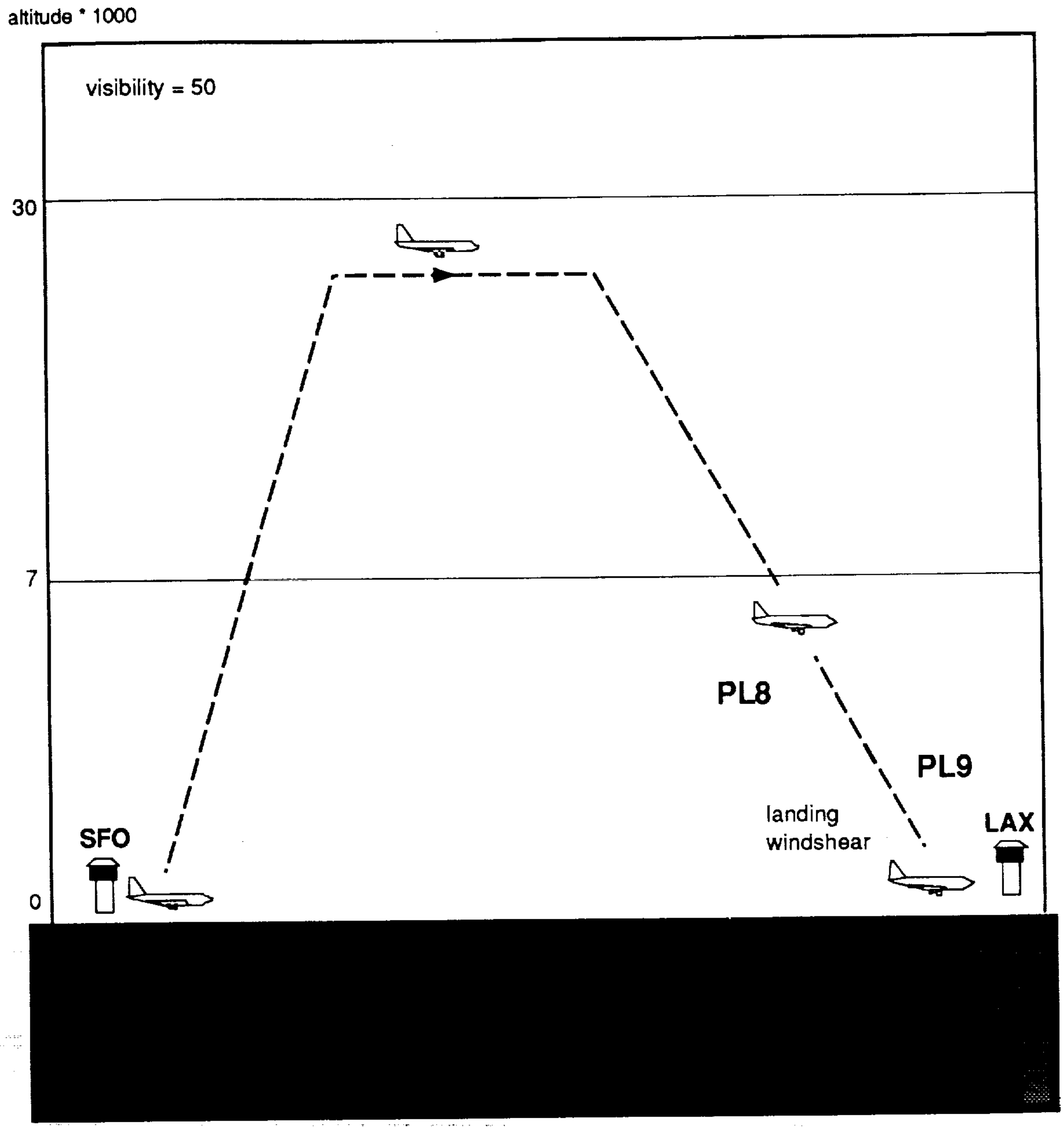

Figure 4.7 PLI Simulation Flight Profile - LEG 3

A typical simulation sequence originating from LAX would proceed as follows. After being dispatched from LAX to SFO, the crew performs a normal preflight and startup. While taxiing to the active runway, the subjects encounter the ground taxiway intersection traffic described in PL1. Once reaching the active runway, the crew is instructed to taxi into position and hold, after which the traffic conflict on the active runway from PL2 is invoked during the subject's takeoff roll. During the climb to cruise, the turbulence report described in PL3 is transmitted. The flight proceeds normally until reaching the SFO terminal area. On short final during the approach to landing, the crew encounters the disabled aircraft blocking the runway (PL4) and is forced to go-around and enter a holding pattern. An FMC failure forces the crew to execute the hold manually (since the holding page on the advanced cab CDU was unavailable). The holding EFC validity (PL5) and the traffic watch while holding (PL6) events occur during the hold and a diversion to SMF is made after the determination that the SFO airport will be closed indefinitely. The short flight to SMF occurs without incident and the crew makes a normal arrival and landing.

The crew is then dispatched from SMF to SFO and proceeds with a normal start-up, taxi out, and takeoff. During climbout, they encounter the crossing traffic described in PL7. The remainder of the flight to SFO occurs without incident and terminates in a normal arrival.

On the last leg, the flight is dispatched from SFO to LAX. A normal start-up, taxi, and takeoff occur, however, during climbout the background ATC contains multiple information elements indicating that at least two other aircraft (one ahead, one behind) are on the same route as the subject. This situation continues throughout the flight during all ATC route and altitude amendments, as well as frequency change handoffs. Shortly after arrival into the LAX terminal area, PL8 occurs when the controller neglects to issue an expected vector to the subject. After being re-vectored, cleared for the approach, and switching to the tower frequency, windshear related airspeed loss advisories from previous arrivals are transmitted, resulting in PL9. The crew either elects to make a normal landing despite the windshear conditions, or executes a missed approach and is subsequently vectored to a normal landing.

To counterbalance learning effects, each crew flew one of the following flight leg rotations initiating in either LAX or SMF.

LAX-SFO(divert to)-SMF		SMF-SFO
SMF-SFO	OR	SFO-LAX
SFO-LAX		LAX-SFO(divert to)-SMF

4.3.3. Measurements

The experimental objectives were investigated using observational, flight performance, and subjective measures. Audio and video recordings were made to monitor intra-cockpit conversation and note any explicit responses to the PLI provided, including decision making and/or increased levels of preparedness. Flight path and control input data were recorded to investigate any difference between cases with and without PLI. Observations were recorded by experimenters located in a separate room containing a video monitor. Information on the monitor included three different camera angles of the simulator interior: captain's flight displays, first officer's flight displays, and a wide angle view. Resolution was clear enough to observe any switch movements, but not clear enough to read the onboard status displays. Other information displayed on the video monitor included: airspeed, altitude, heading, vertical speed, current checklist, flap position, and a running chronometer indexed to the beginning of the flight leg. Audio information contained both intra-cockpit and ATC communications. Subjective opinion measures were obtained during an out-interview where subjects were asked to rank and comment on the importance of PLI in their performance and responses to the various scenarios.

For the data collection runs, the crews were alone in the simulator. However, if any technical or "maintenance" question arose, including simulator problems, they were provided a "company" frequency with which they could obtain information. In the simulator control room, the simulator engineers monitored and recorded all video, audio, flight and status displays, switch positions, and flight path data* from before the first checklist was read to after the final checklist was complete.

*Switch position and flight path data included: altitude, airspeed, groundspeed, geographical position (latitude and longitude), flight control input, engine power settings, flaps, landing gear, radios, and all other switch positions.

4.4. Experimental Procedure

Each experiment lasted 1 and 1/2 days. The experimental protocol called for 1/2 day of training (4 hours) in procedures of the advanced cab in the MVSRF, a full day of data runs (8 hours), and out-interviews (1-2 hours). Crews were subject to one of two different patterns based on when they were scheduled to arrive at the simulation facility.

<u>Morning arrival</u>
day 1 - 1/2 day training and 1/2 day data runs
day 2 - 1/2 day data runs

<u>Afternoon arrival</u>
day 1 - 1/2 day training
day 2 - full day of data runs

The two counterbalanced rotations were distributed as evenly as possible among the crews starting in the morning and those starting in the afternoon. Also, a short break was taken between each flight leg during the data runs.

4.4.1. Training

Upon arrival, the subjects were given 1/2 day of training in the advanced cockpit. This consisted of difference training on the advanced cab systems, basic flight maneuvers, visual and instrument approaches, and navigation to SFO from SMF. The subjects were also given a basic briefing on advanced cab systems, electronic checklist, and datalink communications procedures. During the training sessions, an instructor pilot was present in the simulator with the crews. The flight maneuvers allowed the crews to become familiar with the sidestick control and to get a "feel" for the flight dynamics. The visual and instrument approaches provided an opportunity for the crews to become familiar with the simulator visual display (view outside) and enabled them to practice approaches and landings, and tracking the ILS. The navigation exercises allowed the crew to familiarize themselves with the advanced cab FMC system and CDU programming.

4.4.2. Experimental Run

The subjects participated in the three leg simulation while crew response was monitored through audio, visual, and flight path data and observation notes. The responses to each party line element for each crew were analyzed according to level of awareness and the results of all crews were grouped and ranked.

4.4.3. Post Experiment Out-Interviews

Post experiment out-interviews were conducted to obtain subjective responses to the scenarios and the advanced cab, and to examine differences between perceived and actual reactions. These interviews also provide insight into reasoning behind responses and subjective preferences.

4.5. Results

4.5.1. Subjects

Seven air carrier crews participated in the experiment. One "leg" of data was missed from one crew due to technical difficulties (and resulting scheduling problems) with the MVSRF. Also, a PL2 event from one crew was discarded because of a controller-script error. The subjects consisted of 8 captains and 6 first officers with a mean flight experience of 9086 hours. The subjects were employed by the same air carrier since flight crews from the same airline tend to use standardized procedures that are independent of aircraft type. Those chosen to participate in the experiment were guaranteed individual anonymity.

There were two mixed parings within crews, (e.g. a 737-300-qualified captain flew with a 757-qualified first officer, etc.). Mixed crews often resulted in one crewmember being more familiar with the advanced cab systems because the procedures of different aircraft vary. Consequently, the resulting proficiency imbalance may have subjected the mixed crews to a difference in overall workload level which may have influenced the results.

4.5.2. Analysis of Events and Scoring

Each PLI event was analyzed to determine if the scripted party line information resulted in any change in crew level of awareness and if the information elicited any action. Consideration was given to intra-crew and ATC-crew discussion, a change in aircraft system status, increased preparedness for an anticipated situation, or aircraft flight path adjustments made in response to other aircraft/controller voice transmissions. Subject awareness and reactions for each PLI event were determined from the following sources:

1) Observation notes

As many as three NASA-Ames researchers recorded observation notes of displayed video and audio information while the experiment was in progress.

2) Intra-cockpit and ATC audio track analysis

Audio track content of conversation among the subjects as well as communications between the subjects and ATC was recorded.

3) Video Tape Analysis

Video Tape content of crew actions such as increased out-of-the-window vigilance and switch and control actuation.

4) Discrete switch and control positions

All switch and control positions were recorded as well as flight control stick force and direction input.

5) Flight path data

Aircraft positional, altitude, velocity, and acceleration data were recorded.

The responses to each party line event stimulus were scored based on observations using the criteria shown in Figure 4.8, which spanned the range from (1) no response to (5) positive action taken. The incremental values (2,3, and 4) corresponded to increasing levels of awareness of the event within non-action responses.

		SCORE
NOT AWARE	No indication of response to transmissions............................	1
AWARE	Passive awareness, no indication of detailed understanding of event.	2
	General awareness, indication of detailed understanding but no action taken.	3
	Passive action, crew discussion of alternate course of action and/or increased preparedness.	4
ACTION TAKEN	Change of system status, flight path adjustment or query to ATC in response to Party Line stimulus.	5

Figure 4.8 Crew Response Scoring Criteria

The primary analysis was completed by an experienced B767 first officer and spot checked by a second experienced pilot. The analysis was also reviewed by several NASA-Ames psychologists. The scoring methodology and complete analysis of all events are contained in Appendix F.

4.5.3. *Results of Party Line Event Analysis*

Examination of the video, audio and observation data revealed certain responses that were common for each party line event.

PL1 Aircraft holding short at taxiway intersection

For the aircraft holding short at taxiway intersection event, most crews increased their out-of-the-window vigilance, while two crews went so far as to stop the aircraft until the matter was clarified.

PL2 Aircraft crossing active runway while subject is lined up for takeoff

No crews detected the aircraft crossing the active runway. These observations were supported in the out-interview briefings.

PL3 Turbulence and weather deviations

Turbulence and weather deviations typically resulted in the crews turning on the fasten seat belt sign, with some crews querying ATC: "where's that aircraft?" in response to a turbulence report by traffic ahead.

PL4 Aircraft on runway of intended landing

All of the crews engaged in discussion concerning the aircraft on runway of intended landing and increased their preparedness for a possible go-around. However, all crews executed go-arounds only after being instructed to do so by the tower, i.e. no go-arounds were self-initiated.

PL5 Holding EFC validity

In the holding EFC validation event, most crews made the decision to divert immediately after the hour and a half holding delays were issued by ATC to other aircraft holding below.

PL6 Traffic watch while holding

In the holding pattern, crews were occupied with the task of considering diversion options and fuel quantity status and consequently most were unaware of the traffic approaching their position. Those that were aware, however, appeared to cue on the phrase "violating holding airspace" issued to the encroaching traffic by ATC.

PL7 Traffic watch during climb

In the traffic watch during climb event, most crews increased their outside vigilance as they attempted to make visual contact with the approaching traffic based on the ATC transmissions to the other aircraft.

PL8 Aircraft sequencing

In the aircraft sequencing event, many of the crews were aware that they were in a sequence of arrivals, but none detected the missed turn or questioned ATC.

PL9 Windshear on final approach

All of the crews responded to the reports of windshear on final approach issued by previous arriving aircraft. In addition to discussing a possible go-around, they made approach reference speed adjustments and in many cases reviewed the windshear escape maneuver. The responses occurred after switching to the tower frequency where the windshear PLI was available. No action was taken based on the airport ATIS information which was obtained earlier in the flight while the crew was still monitoring approach control. The ATIS information contained no windshear data.

After rating each party line element as described in Section 4.5.2, the responses of all crews are summarized in Table 4.2 in the three broad categories of not aware, aware, and action taken.

PLI EVENT #		NOT AWARE	AWARE	ACTION TAKEN
1	Aircraft hold short at taxiway intersection	1	4	2
2	Aircraft crossing active runway	6	0	0
3	Turbulence and weather deviations	1	1	5
4	Aircraft on runway of intended landing	0	7	0
5	Holding EFC validity	0	1	6
6	Traffic watch while holding	5	2	0
7	Traffic watch during climb	1	6	0
8	Aircraft Sequencing	1	5	0
9	Windshear on final approach	0	0	6

Table 4.2 Party Line Event Results Summary

4.5.4. Analysis of Relative Party Line Event Responses

In order to assess which elements were most effective in inducing action responses, the scores from Table 4.2 were ranked by action taken in Table 4.3.

PLI EVENT	NOT AWARE	AWARE	ACTION TAKEN
Windshear on final approach	0	0	6
Holding EFC validity	0	1	6
Turbulence and weather deviations	1	1	5
*Aircraft hold short at taxiway intersection	1	4	2
*Aircraft on runway of intended landing	0	7	0
*Traffic watch during climb	1	6	0
*Aircraft Sequencing	1	5	0
*Traffic watch while holding	5	2	0
*Aircraft crossing active runway	6	0	0

* = Traffic related

Table 4.3 Ranked PL1 Event Results

Windshear, holding EFC validity, and *turbulence and weather deviations* rated the highest and all resulted in action responses from the subjects. This finding is in agreement with the results from the "importance" section of the survey where the same items rated among the most important. The high crewmember response to windshear reports, especially if they include previous go-arounds, indicates possible areas for procedural changes. For instance, since many crews appeared to cue on the reports of the go-around by the previous arrival, it may be advantageous for ATC to simply report previous go-arounds as a standard procedure without the need to speculate on cause or wait for a formal pilot report (PIREP).

The top three elements are all strategic events where pilots often have time available to make decisions. In the case of *windshear*, strategic planning includes exercising the necessary precautions to completely avoid the windshear or adjust flight parameters to minimize any adverse windshear effects.

The lowest awareness occurred for the bottom two events, *PL2 - aircraft crossing the active runway* and *PL6 - traffic watch while holding*. For these two events the amount of PLI assimilated was minimal. Both occurred in high workload situations where the crew's attention and cognitive capacity was absorbed by the tasks at hand, specifically, setting the takeoff power and considering diversion options while holding. The ability for flight crewmembers to assimilate PLI appears to vary with workload, time available, and the strategic/tactical situation. There appears to be greater PLI utilization for strategical decision making in low workload conditions, and low PLI assimilation in short term high workload tactical situations like takeoff roll (*PL2*). In this case, the party line information was transmitted when the crew's attention was focused on other duties.

The items indicated by an asterisk (*) in Table 4.3 are all tactical traffic related events. They all elicited very low action responses by the subjects. These items are normally the responsibility of the air traffic controller and pilots are only required to "take action" in unusual circumstances. Because of the dynamics of the professional relationship between flight crewmembers and air traffic controllers, pilots are often reticent to insinuate that a controller error has taken place. The low number of action responses may also be due to the low level of confidence pilots have in using PLI for detecting controller errors as indicated in the survey. As a consequence, the crews were reticent to take action but often were aware and did indicate increased vigilance. An additional factor may be that action based on an incorrect interpretation of PLI in some traffic related cases had a higher penalty than the non-traffic relevant events. For example, in the case of *weather deviations* (a "non-traffic" event), the crew was required to get approval from the controller. Therefore, even if the deviation was unnecessary, no serious penalty was incurred since permission to execute the deviation was obtained from ATC.

For traffic events such as *aircraft sequencing*, crews often receive spacing vectors that might seem inappropriate from their vantage point, but rarely question the ATC instructions under the assumption that the controller has the "big picture" and any disruption might impede the smooth flow of traffic or cause an aircraft separation problem. This may explain the experimental observation that PLI utilization in cases involving scripted controller oversights (such as *PL8*) rarely resulted in any positive action taken by flight crews.

The high action responses of the terminal area or "near airport" party line events from the simulation study (*windshear*, *holding*, and *airport ground events*) are consistent with the high importance and accuracy ratings these items had in the survey results. These results reinforce the need to proceed cautiously when considering datalink implementation in the terminal area and final controller segments.

4.5.5. Flight Path Analysis

Flight path data was compared between PLI (voice) and non-PLI (datalink) cases to examine any significant differences. The Party Line Event *PL4 traffic on runway of intended landing* was examined where the flight path performance during the controller initiated go-around was analyzed.

In both voice and datalink cases the subjects were vectored for the approach in an identical manner. In the voice case, a conversation between a previous arrival and the tower concerning clearing the active runway was transmitted over the tower frequency during the subject's final approach. In both cases, as the approach continued, the subject broke out of the overcast and was presented with simulated visual traffic on the runway. Since no crews self-initiated a go-around, the tower instructed them to do so at the same point in the approach. In each case, the time and altitude when the go-around instructions were issued were used as a common datum for analysis of the subsequent flight paths.

The data collected included the time and altitude (t_1, h_1) that the go-around instructions were issued by ATC, and the time and altitude (t_2, h_2) of the point of minimum height above the ground (the distance between the bottom of the flight profile arc and the ground). For the datalink case, the issuance of the go-around instructions by ATC was defined as the time of the datalink chime (used to alert the crew of the arrival of a datalinked message) for the "go-around" datalink message. For the voice case, the time of issuance was defined as the time when the controller began transmitting the go-around instructions to the flight crew. The results are presented in Table 4.4 along with the differences in time and altitude (t_d, h_d) between the "go-around" instruction point and the minimum altitude point. These correspond to the crew response time (t_d) and altitude lost during the go-around maneuver (h_d). The time units are seconds indexed to the beginning of the simulation and the altitude units are feet above the ground.

CREW	t_1 (sec)	t_2 (sec)	t_d (sec)	h_1 (ft)	h_2 (ft)	h_d (ft)
Voice 1	6285	6289	4	285	261	24
Voice 2	6758	6764	6	295	249	46
Voice 3	6607	6612	5	312	281	31
Voice 4	5991	6000	9	355	275	80
Voice 5	6740	6748	8	319	250	69
Voice 6	6029	6033	4	191	153	38
Datalink 1	5747	5758	11	475	372	103
Datalink 2	21460	21468	8	286	208	78
Datalink 3	5923	5933	10	356	277	79
Datalink 4	6149	6158	9	299	217	82
Datalink 5	6755	6762	7	282	246	36
Datalink 6	5929	5934	5	297	262	35

Table 4.4 Voice/Datalink Flight Path Data

The means and standard deviations from Table 4.4 are as follows.

	Mean	Standard Deviation
Voice Time to Go-around, t_d	6.0s	2.1
Voice Altitude Lost in Go-around, h_d	48.0s	22.1
Datalink Time to Go-around, t_d	8.3s	2.2
Datalink Altitude Lost in Go-around, h_d	68.8s	27.4

As can be seen from the results, there exists an average 2.3 second difference in response times between the voice and datalink cases. The slower response in the datalink cases is thought to be due to three possible causes: (1) the time required for the crews to read the datalinked go-around message, (2) the influence of prosodic voice inflection in the verbal go-around instructions, and (3) the enhanced preparedness resulting from the awareness provided by PLI (note: all voice crews indicated awareness of the aircraft from PLI data).

The relative importance of the datalink reading delay, and the influence of PLI and prosodic effects cannot be resolved from this preliminary study. However, the presence of the 2.3 second lag in the datalink case indicates that for some time critical ATC instructions, voice transmissions offer potential time advantages over datalinked transmissions. This observation suggests consideration should be given for the retention of voice in the datalink environment for time critical or emergency communications.

5. Summary of Conclusions

A pilot opinion survey was distributed to study the perceived importance of party line information and a flight simulation experiment was conducted to investigate PLI assimilation and usage in pilot situational awareness. The major conclusions of this research are summarized below.

Conclusions from the Pilot Opinion Survey:

1. PLI is perceived as important by flight crewmembers as indicated by the high mean importance scores in the survey. The perceived importance of a given party line information element varied among different phases of flight. Those items concerned with the Terminal Area and Final Approach phases tended to be higher in importance than the other phases.

2. PLI containing weather situation information was perceived as most important, followed by holding information. Communication related general PLI elements such as call sign confusion and controller urgency were also perceived as very important.

3. The top scoring importance items from the survey are associated with an aircraft's arrival, which is often the most time critical phase of flight. The time critical nature of arrival activities (including minimizing "heads down" time in order to provide for an adequate traffic watch) and the high importance attributed to party line information in the terminal area, suggest that the final tower controller frequency is a less desirable candidate for initial datalink implementation than other "enroute" operations.

4. The elements involving strategic planning: weather situations, holding situations, and ride reports scored higher in importance. Elements which contain information typically used for tactical planning such as traffic watch and controller errors, were also rated as important, but scored somewhat lower.

5. Party line information which allows detection of controller errors is perceived as important by pilots but not very reliable. Controller errors consistently scored lowest in terms of perceived reliability among all phases in the survey which indicates pilots do not have confidence that controller errors can be reliably detected from party line information.

6. Pilots appear to be more receptive to the implementation of datalink if consideration for the use of compensation is given.

Conclusions from the Full Mission Flight Simulation:

1. The three PLI elements which scored highest in the survey (*windshear*, *holding EFC validity*, and *deviations for turbulence or weather*) all resulted in action responses from the subjects during the simulation study. These are all situations where pilots had time available to assimilate information and make decisions (action in the *windshear* event consisted mostly of increased preparedness and planned approach speed adjustments made during the pre-approach phase when time was available).

2. The lowest assimilation of the party line information occurred for the *aircraft crossing the active runway* and the *traffic watch while holding* events. Both events occurred in high workload situations where the crew's attention and cognitive capacity was absorbed by the tasks at hand, specifically, setting the takeoff power and considering diversion options while holding.

3. PLI appeared to have greater utilization for strategical decision making in low workload conditions, and not in short term high workload tactical situations like the takeoff roll.

4. In the flight simulation study, PLI was utilized to a lesser extent in those decisions involving limited options or where the penalty for an incorrect interpretation was greatest.

5. PLI utilization in cases involving potential controller oversights rarely resulted in any positive action taken by flight crews during the simulation. This is thought to

be due to the dynamics of the ATC-flight crew professional relationship since pilots were often reticent to insinuate that a controller error had taken place.

6. Datalink-only crews responded an average of 2.3 seconds slower than the voice only crews to a "go-around" instruction issued by ATC in response to an aircraft on the runway. All of the voice-only crews indicated awareness of the situation from PLI, however other factors such as the time to read the datalink message and prosodic effects may also have influenced the results. Still, the presence of a notable lag in the datalink case indicates that for some ATC instructions, voice transmissions offer certain time advantages over datalinked transmissions. This observation suggests consideration should be given for the retention of voice in the datalink environment for time critical or emergency communications.

7. The high utilization of PLI for the terminal area or "near airport" party line events in the simulation study (*windshear*, *holding*, and *airport ground events*) was consistent with the high importance of these items in the survey. The importance and utility of PLI near the airport indicates the need to proceed cautiously when considering datalink implementation in the terminal area and final controller segments.

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Appendix A:

ATC Communication Analysis

A.3. Results

Recordings were made between September, 1990 and March, 1991, during peak and off-peak traffic conditions and in various weather conditions . Each tracked flight resulted in approximately 20 minutes of recorded air/ground communications and included the three sequential sectors: enroute center control frequency, approach control frequency, and the control tower frequency.

Analysis of Recordings

The recordings of the VHF air ground communications were analyzed for type and quantity of PLI present. The tapes were reviewed by an experienced pilot and checked by a second pilot. While the tapes were being reviewed, the arrival sequence of every aircraft on the frequency was noted and each two-way communication interaction or "transaction" between ATC and any flight on the frequency was categorized by type according to Table A.1. The "General" list was applied for all communications while the "Tower/ Departures" list only involved tower frequency communications which included both arriving and departing aircraft. Note, with the exception of the last item, all items of both lists are considered *potential* PLI. All of the communications were categorized using the groups in Table A.1, however, any communications that did not have the *potential* to be used as PLI by the tracked flight was so identified.

General	Tower/Departures
Next comm freq	Landing clearance
Sequencing (routing, altitude, airspeed)	Landing wind check
Informational transmissions	Hold short instructions
Weather situations	Takeoff clearance
Approach clearance	Position and hold instructions
Traffic watch	Runway exit/ground control contact
Requests	Departure control handoff
Ride reports	
Holding situations	
Sector check in	
Miscellaneous non-PLI transmissions	

Table A.1 Pilot/ATC Transaction Categories

The communication transactions were then tallied and ratios of potential PLI transmissions to total transmissions were determined. There is some ambiguity to defining what is pertinent PLI for a given flight. For example, it is not clear whether sector check in or ride report PLI from an aircraft sequentially behind the tracked flight provide any useful information. For this analysis, *potential* PLI was defined as *any* information which could be useful as PLI. This then defines an upper limit of available PLI

The results of all the recorded flights, including the weather and total transaction count, are presented in Table A.1. For three of the flights the center sector communications were unavailable due to reception problems. The ratios for each sector contain all potential PLI transmitted, including those involving aircraft sequentially behind the tracked flight. Therefore, the ratios are biased towards an upper limit of potential PLI.

Flight #	Weather	Total TX's	Center	Approach	Tower	All Sectors
UA69	38BKN	115	0.67	1.00	0.79	0.91
AA391	38BKN	158	0.89	1.00	0.77	0.95
AA277	VFR	118	0.95	1.00	0.86	0.96
UA77	CAVU	38	0.85	1.00	0.75	0.89
AA783	CAVU	124	0.71	1.00	0.79	0.80
AA41	CAVU	43	0.90	1.00	0.71	0.86
UA955	7OVC	82	1.00	1.00	0.80	0.98
NW173	7OVC	119	1.00	1.00	0.83	0.98
UA883	11OVC	63	1.00	1.00	0.80	0.98
SI156	RVR20	81		1.00	0.75	0.94
AA303	RVR20	45		1.00	0.86	0.98
AA175	W5S	84	0.78	1.00	0.52	0.76
UA765	W5S	128	0.71	1.00	0.65	0.80
AA341	XM12OVC	90	0.47	1.00	0.69	0.73
UA63	BS-MVFR	37		1.00	0.80	0.97
SAB563	M19BKN	76	0.72	1.00	1.00	0.91
AA581	VFR	90	0.80	1.00	0.75	0.88
UA81	VFR	86	0.95	0.94	0.73	0.92
AA53	VFR	65	0.60	1.00	1.00	0.91
AA783	VFR	88	0.88	1.00	0.87	0.92
AVG		**86.5**	**0.81**	**0.99**	**0.79**	**0.90**
SDEV		33.03	0.15	0.01	0.11	0.08

Table A.2 PLI Communications Ratios

As can be seen, the overall percentage of potential PLI transmissions was approximately 90%. The ratio of potential PLI to total transmissions for the center sector is somewhat lower due to the larger number transient (non-arriving) aircraft. In the approach control sector almost all of the communications contained potential PLI. Most of the non-PLI transmissions from the tower sector included frequency change instructions given by the tower to departing aircraft. If these were to be included in the tower ratios, then almost all of the communications on this sector could be classified as potential PLI also.

Peak and off-peak traffic periods are indicated by the number of total transmissions for a given tracked flight (since the recording time is approximately the same for each arrival). There does not appear to be any significant trends in the fraction of transmissions containing potential PLI with respect to weather conditions or peak/off-peak traffic conditions. However, if the amount of useful or critical PLI transmissions in a sector increased, the effect of weather and traffic conditions may be more pronounced.

Appendix B:

Survey of Datalink ATC Message Exchange

DEPARTMENT OF
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ROOM 37-438 (617) 253-0993
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Fellow ORD Crewmember:

I am currently an ORD based 767I F/O (Boston commuter). While I am not flying (which I usually try to do on weekends), I attend graduate school full time in the Department of Aeronautics and Astronautics at MIT where I am pursuing a Master's degree in Aeronautics. In addition to my classes, I work in the Aeronautical Systems Laboratory as a research assistant where I am carrying out the research for my Master's thesis . The research involves human factors issues in the implementation of ATC datalink message exchange. As you may know, the FAA's National Airspace Plan for the 1990's involves full utilization of datalink weather services, ATIS, and ATC clearances/amendments. The initial implementation of this is the pre-departure clearance program that we are now utilizing at ORD, DFW, and SFO.

The purpose of the attached survey is to obtain the pilot's perspective on whether or not certain communication elements in the current ATC environment are significant. I feel that it is important to get our input anytime the implementation of a new technology has the potential of changing an existing mode of operation as much as this does. We, as pilots, will be the ones who have to work in the environments that others implement so it is important for us to take advantage of any opportunity we can to influence the design of future systems. Researchers value the opinions of pilots concerning new systems but in the past it has been difficult to get large scale input due to the nature of surveying.

The results of the survey will be used in my thesis which in turn will be utilized by NASA-Ames human factors group to help in determining guidelines for datalink implementation. It should be noted that this study is being funded by a grant from NASA-Ames and is being carried out by the Aeronautical Systems Lab at MIT. The research is completely independent of AAL and the APA although both Carl Price of AAL and Mike Shanholtz of the APA are aware of and support the study. If you find the time to complete this survey, please return it to the marked box above my ORD mailbox.

Thanks,

Alan H. Midkiff
AA#13360

SURVEY ON
DATALINK ATC MESSAGE EXCHANGE

The Department of Aeronautics and Astronautics at the Massachusetts Institute of Technology is currently evaluating ATC message exchange using digital datalink. ATC communications via the datalink would be displayed either textually or graphically in the cockpit thus minimizing the need for voice communications and relieving congested radio frequencies.

Among the many facets being studied in this research is the significance of "party line" information, which pilots acquire by overhearing messages intended for other aircraft. In the datalink environment, the availability of such information may be minimal due to the reduction of voice communications. The purpose of this survey is to obtain a general outlook on the presence of party line information to pilots relative to the environment in which they are operating.

In the survey you are asked to rank the importance, availability, and accuracy of the information derived from party line for various phases of a typical flight, and for a few miscellaneous items. In addition, there is a free comment area, a few datalink questions, and a background section.

Participation in this survey is completely voluntary. It is not necessary to give your name at any point. You may decline to answer any of the questions in this survey, without prejudice. All surveys will be de-identified and all information obtained from any individual survey will be kept confidential by the researchers at MIT.

For further information about this study, please feel free to contact:

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Thank you for your time and cooperation.

PARTY LINE INFORMATION

Select the appropriate number which, in your opinion, best describes the importance, availability, and accuracy of **party line information** in the current ATC environment with reference to the listed phases of flight.

PHASE OF FLIGHT	IMPORTANCE (trivial – critical)	AVAILABILITY (non-existent – common-place)	ACCURACY (unreliable – reliable)
Ground Operations: *dispatch, pre-start, taxi*			
next comm freq	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
routing to runway	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
ground sequencing	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
taxi "hold short" instructions for other a/c	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
a/c crossing active runway while you are lined up for takeoff	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
controller errors	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
other____________	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Departure: *takeoff to top of climb*			
next comm freq	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
weather situation (including deviations)	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
ride reports/turbulence	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
traffic watch	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
controller errors	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
other____________	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Cruise			
next comm freq	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
weather situation (including deviations)	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
ride reports/turbulence	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
winds aloft	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
traffic watch	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
sequencing	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
controller errors	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
other____________	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5

PARTY LINE INFORMATION (cont.)

PHASE OF FLIGHT	IMPORTANCE (trivial – critical)	AVAILABILITY (non-existent – common-place)	ACCURACY (unreliable – reliable)
Descent: *top of descent to approach control contact*			
next comm freq	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
weather situation (including deviations)	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
ride reports/turbulence	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
traffic watch	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
sequencing	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
holding situations/EFC validity	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
controller errors	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
other______________________________	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Terminal Area: *approach control contact to final approach fix*			
next comm freq	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
weather situation (including deviations)	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
ride reports/turbulence	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
traffic watch	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
sequencing	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
holding situations/EFC validity	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
terminal routing/runway assignments	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
approach clearance	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
controller errors	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
other______________________________	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Final Approach: *final approach fix to runway threshold*			
next comm freq	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
weather situation (minimums)	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
traffic watch	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
sequencing	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
missed approach - weather induced	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
missed approach - other	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
windshear	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
aircraft on your landing runway	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
braking action	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
taxiway turnoff	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
other______________________________	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5

MISCELLANEOUS PARTY LINE INFORMATION

Select the appropriate number which, in your opinion, best describes the importance, availability, and accuracy of the following miscellaneous **party line** items in the current ATC environment.

	IMPORTANCE trivial — critical	AVAILABILITY non-existent — common-place	ACCURACY unreliable — reliable
Sector congestion (as indicated by frequency congestion)	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Controller's experience level inferred from tone of voice and speech patterns	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Pilot's (of other aircraft) experience level inferred from tone of voice and speech patterns	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Controller's "level of urgency" inferred from tone of voice and speech patterns	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Pilot's (of other aircraft) "level of urgency" inferred from tone of voice and speech patterns	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Background ATC transmissions used as reassurance of being "in contact" with the controller. ("Anybody out there?")	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Call sign confusion (other aircraft accepting your clearance or vice versa)	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
ATC facilities and problems/lost communications	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Navaid facilities and problems	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Other______________________	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5

ADDITIONAL PARTY LINE QUESTIONS

Considering the advantages of datalink (i.e. quiet frequency, discrete aircraft addressing, frequency congestion relief, unambiguous clearances, etc.) and of party line information (situational/environmental awareness, traffic/ride information, etc.), would you tend to support a datalink environment or the current environment containing party line information (PLI)?

Choose one:

1	2	3	4	5
DATALINK ONLY		EQUAL DISTRIBUTION VOICE / DATALINK		VHF VOICE COMMUNICATION ONLY (PLI)

If some mechanism could be developed to datalink critical PLI to the aircraft (eg. a status display with current wx, sequencing, and/or holding information), would you tend to support a datalink environment or the present PLI environment?

Choose one:

1	2	3	4	5
DATALINK ONLY		EQUAL DISTRIBUTION VOICE / DATALINK		VHF VOICE COMMUNICATION ONLY (PLI)

Additional comments (use the back of this page if necessary):

Are you TCAS qualified? ____YES ____NO If so, please comment on the effectiveness of TCAS as a compensational device for situational awareness, sequencing, and traffic watch in the datalink environment.

Please provide any ideas you might have or like to see concerning datalinking PLI to the aircraft.

Enter any comments about the significance of party line information, e.g., what benefits and/or problems do you think you encounter that were not included on the previous pages (use back if necessary).

BACKGROUND INFORMATION

How long have you been employed as a professional pilot?______ yrs

What is your total number of flying hours? ______________

Your flying background is primarily ______ military ______ non-military (choose one).

What is your age? _______

How long have you been flying with American Airlines? _______ yrs _______mos

Please estimate all flight hours in your current and previous aircraft (including your experience with other airlines and/or military flying) and indicate your crew position on that aircraft.

Current	Type____________	Hrs. in Seat	_______CAPT	_______F/O	_______S/O
Immediat prior	Type____________	Hrs. in Seat	_______CAPT	_______F/O	_______S/O
Other	Type____________	Hrs. in Seat	_______CAPT	_______F/O	_______S/O
Other	Type____________	Hrs. in Seat	_______CAPT	_______F/O	_______S/O
Other	Type____________	Hrs. in Seat	_______CAPT	_______F/O	_______S/O
Other	Type____________	Hrs. in Seat	_______CAPT	_______F/O	_______S/O
Other	Type____________	Hrs. in Seat	_______CAPT	_______F/O	_______S/O
Other	Type____________	Hrs. in Seat	_______CAPT	_______F/O	_______S/O

Do you use a personal computer? _____ YES _____ NO

How satisfied are you with predeparture clearances through the ACARS datalink? Include any additional comments.

Appendix C:

Survey Results Tabulation

PARTY LINE SURVEY RESULTS (N=184)

IMPORTANCE

	Mean		Standard Deviation	
Ground Ops	a/c crossing active rwy	4.65	a/c crossing activ rwy	0.69
	other a/c "hold short"	4.06	ground sequencing	1.04
	controller errors	4.01	other a/c "hold short"	1.09
	routing to rwy	3.45	controller errors	1.10
	ground sequencing	3.27	next comm freq	1.13
	next comm freq	2.60	routing to rwy	1.15
Departure	wx situation	4.40	wx situation	0.70
	ride reports	4.06	ride reports	0.84
	traffic watch	3.92	traffic watch	1.07
	controller errors	3.91	controller errors	1.10
	next comm freq	2.90	next comm freq	1.14
Cruise	wx situation	4.38	wx situation	0.68
	ride reports	4.10	ride reports	0.76
	controller errors	3.63	winds aloft	0.98
	traffic watch	3.36	sequencing	1.04
	sequencing	3.04	next comm freq	1.08
	winds aloft	2.85	controller errors	1.17
	next comm freq	2.70	traffic watch	1.17
Descent	wx situation	4.41	wx situation	0.63
	hold situation/EFC	4.08	ride reports	0.82
	traffic watch	3.98	hold situation/EFC	0.88
	ride reports	3.97	sequencing	0.93
	controller errors	3.82	traffic watch	1.01
	sequencing	3.48	next comm freq	1.07
	next comm freq	3.08	controller errors	1.11
Terminal Area	wx situation	4.47	wx situation	0.61
	traffic watch	4.22	terminal routing	0.81
	approach clearance	4.16	sequencing	0.85
	terminal routing	4.09	traffic watch	0.91
	hold situation/EFC	4.01	approach clearance	0.91
	controller errors	3.97	hold situation/EFC	0.91
	ride reports	3.86	ride reports	0.92
	sequencing	3.82	controller errors	1.13
	next comm freq	3.46	next comm freq	1.15
Final Approach	windshear	4.87	windshear	0.34
	a/c on your ldg rwy	4.81	a/c on your ldg rwy	0.49
	braking action	4.63	braking action	0.53
	missed approach-wx	4.61	missed approach-wx	0.69
	wx situation	4.50	wx situation	0.83
	go around	4.32	go around	0.85
	traffic watch	4.09	traffic watch	1.05
	sequencing	3.71	sequencing	1.06
	taxiway turnoff	3.46	taxiway turnoff	1.17
	next comm freq	3.26	next comm freq	1.29

ACCURACY

	Mean		Standard Deviation	
Ground Ops	a/c crossing active rwy	4.12	a/c crossing activ rwy	0.88
	next comm freq	3.85	other a/c "hold short"	0.90
	other a/c "hold short"	3.81	next comm freq	0.97
	routing to rwy	3.64	controller errors	0.97
	ground sequencing	3.50	routing to rwy	0.99
	controller errors	3.26	ground sequencing	0.99
Departure	ride reports	3.74	ride reports	0.79
	wx situation	3.71	wx situation	0.82
	next comm freq	3.63	traffic watch	0.95
	traffic watch	3.40	controller errors	1.02
	controller errors	3.00	next comm freq	1.09
Cruise	wx situation	3.83	ride reports	0.77
	ride reports	3.81	wx situation	0.81
	next comm freq	3.77	traffic watch	0.91
	traffic watch	3.45	winds aloft	0.95
	winds aloft	3.42	next comm freq	1.00
	sequencing	3.30	controller errors	1.02
	controller errors	2.97	sequencing	1.04
Descent	wx situation	3.89	ride reports	0.75
	ride reports	3.78	wx situation	0.76
	next comm freq	3.77	sequencing	0.83
	hold situation/EFC	3.67	hold situation/EFC	0.85
	sequencing	3.46	traffic watch	0.86
	traffic watch	3.44	controller errors	0.94
	controller errors	3.06	next comm freq	0.98
Terminal Area	approach clearance	4.09	terminal routing	0.77
	next comm freq	4.00	wx situation	0.78
	wx situation	3.91	approach clearance	0.79
	terminal routing	3.84	ride reports	0.83
	ride reports	3.73	sequencing	0.84
	hold situation/EFC	3.66	hold situation/EFC	0.86
	traffic watch	3.63	traffic watch	0.87
	sequencing	3.62	next comm freq	0.91
	controller errors	3.15	controller errors	0.98
Final Approach	a/c on your ldg rwy	4.12	a/c on your ldg rwy	0.77
	next comm freq	4.09	braking action	0.81
	wx situation	4.07	wx situation	0.83
	missed approach-wx	4.06	go around	0.83
	go around	4.02	missed approach-wx	0.86
	braking action	3.91	sequencing	0.87
	windshear	3.84	traffic watch	0.88
	traffic watch	3.79	windshear	0.89
	sequencing	3.79	next comm freq	0.92
	taxiway turnoff	3.38	taxiway turnoff	0.99

AVAILABILITY

	Mean		Standard Deviation	
Ground Ops	a/c crossing active rwy	3.86	other a/c "hold short"	0.94
	other a/c "hold short"	3.82	routing to rwy	0.99
	routing to rwy	3.81	controller errors	1.00
	next comm freq	3.75	ground sequencing	1.05
	ground sequencing	3.40	a/c crossing activ rwy	1.10
	controller errors	2.96	next comm freq	1.15
Departure	ride reports	3.86	ride reports	0.86
	wx situation	3.70	wx situation	0.90
	next comm freq	3.69	traffic watch	0.95
	traffic watch	3.44	next comm freq	1.03
	controller errors	2.81	controller errors	1.06
Cruise	ride reports	3.99	ride reports	0.80
	wx situation	3.86	wx situation	0.84
	next comm freq	3.76	winds aloft	0.94
	traffic watch	3.24	traffic watch	0.95
	sequencing	2.99	controller errors	0.96
	winds aloft	2.79	next comm freq	0.98
	controller errors	2.74	sequencing	1.05
Descent	wx situation	3.83	wx situation	0.83
	hold situation/EFC	3.81	hold situation/EFC	0.86
	next comm freq	3.79	ride reports	0.86
	ride reports	3.77	sequencing	0.91
	traffic watch	3.44	next comm freq	0.93
	sequencing	3.40	traffic watch	0.96
	controller errors	2.94	controller errors	0.97
Terminal Area	approach clearance	4.07	wx situation	0.79
	next comm freq	3.96	approach clearance	0.82
	wx situation	3.94	sequencing	0.87
	terminal routing	3.86	next comm freq	0.88
	hold situation/EFC	3.77	terminal routing	0.90
	traffic watch	3.69	traffic watch	0.90
	ride reports	3.68	ride reports	0.91
	sequencing	3.48	hold situation/EFC	0.92
	controller errors	2.99	controller errors	1.00
Final Approach	wx situation	4.00	wx situation	0.91
	next comm freq	3.98	sequencing	0.91
	a/c on your ldg rwy	3.91	braking action	0.92
	braking action	3.90	traffic watch	0.94
	windshear	3.89	windshear	0.95
	missed approach-wx	3.88	missed approach-wx	0.95
	go around	3.83	go around	0.95
	traffic watch	3.67	a/c on your ldg rwy	0.96
	sequencing	3.64	next comm freq	0.97
	taxiway turnoff	3.25	taxiway turnoff	1.03

BY PHASE

	Mean		Standard Deviation	
Importance	final approach	4.23	terminal area	0.28
	terminal area	4.01	descent	0.43
	departure	3.84	departure	0.56
	descent	3.83	final approach	0.57
	ground ops	3.67	cruise	0.63
	cruise	3.44	ground ops	0.72
Availability	final approach	3.79	final approach	0.23
	terminal area	3.71	terminal area	0.33
	ground ops	3.60	descent	0.33
	descent	3.57	ground ops	0.36
	departure	3.50	departure	0.41
	cruise	3.34	cruise	0.53
Accuracy	final approach	3.91	final approach	0.22
	terminal area	3.74	terminal area	0.28
	ground ops	3.70	descent	0.28
	descent	3.58	ground ops	0.30
	cruise	3.51	departure	0.31
	departure	3.50	cruise	0.32

ACROSS ALL PHASES

	Mean		Standard Deviation	
Importance	wx situation	4.43	wx situation	0.05
	hold situation/EFC	4.04	hold situation/EFC	0.05
	ride reports	4.00	ride reports	0.10
	controller errors	3.87	controller errors	0.15
	traffic watch	3.87	next comm freq	0.33
	sequencing	3.51	sequencing	0.35
	next comm freq	3.00	traffic watch	0.36
Availability	wx situation	3.86	hold situation/EFC	0.03
	ride reports	3.83	controller errors	0.10
	next comm freq	3.82	wx situation	0.11
	hold situation/EFC	3.79	next comm freq	0.12
	traffic watch	3.50	ride reports	0.14
	sequencing	3.38	traffic watch	0.19
	controller errors	2.89	sequencing	0.27
Accuracy	wx situation	3.88	hold situation/EFC	0.00
	next comm freq	3.85	ride reports	0.04
	ride reports	3.76	traffic watch	0.10
	hold situation/EFC	3.67	controller errors	0.12
	sequencing	3.54	wx situation	0.13
	traffic watch	3.48	next comm freq	0.17
	controller errors	3.09	sequencing	0.21

MISCELLANEOUS

	Mean		Standard Deviation	
Importance	call sign confusion	4.53	call sign confusion	0.74
	controller urgency	4.22	controller urgency	0.85
	ATC prob/lost comm	4.22	navaid problems	0.89
	navaid problems	3.96	ATC prob/lost comm	0.93
	other pilot urgency	3.83	other pilot urgency	1.03
	sector congestion	3.70	sector congestion	1.03
	controller exp level	3.43	controller exp level	1.04
	bkgnd reassurance	3.31	other pilot exp level	1.10
	other pilot exp level	3.08	bkgnd reassurance	1.16
Availability	controller urgency	3.93	call sign confusion	0.94
	sector congestion	3.89	sector congestion	0.98
	bkgnd reassurance	3.78	controller urgency	0.99
	call sign confusion	3.71	navaid problems	1.02
	other pilot urgency	3.60	ATC prob/lost comm	1.04
	controller exp level	3.49	bkgnd reassurance	1.07
	ATC prob/lost comm	3.19	other pilot urgency	1.07
	navaid problems	3.19	controller exp level	1.08
	other pilot exp level	3.14	other pilot exp level	1.16
Accuracy	controller urgency	3.73	sector congestion	0.89
	bkgnd reassurance	3.71	ATC prob/lost comm	0.96
	sector congestion	3.61	navaid problems	0.98
	navaid problems	3.59	controller urgency	1.02
	call sign confusion	3.51	other pilot exp level	1.02
	other pilot urgency	3.49	other pilot urgency	1.03
	ATC prob/lost comm	3.40	controller exp level	1.03
	controller exp level	3.06	call sign confusion	1.04
	other pilot exp level	2.78	bkgnd reassurance	1.18

MISCELLANEOUS/BACKGROUND

Deviation	Mean	Standard
DL-PLI	3.03	0.82
DL-PLI with compensation	2.71	0.92
SHIFT (towards "DATALINK ONLY")	0.50	0.81
TCAS (1=unfavorable...3=favorable)	2.18	0.76
PDC (1=unfavorable...3=favorable)	2.83	0.48
AGE	40.8	8.13
AA years	10.1	8.02
Total years	17.0	8.03
Flight experience (total hours)	8914	5027

	Total Number
Captains	86
First officers	77
Second officers	9
Military background	88
Non-military background	89
TCAS qualified	111
EFIS qualified	33
PC user	111

Appendix D:

Statistical Analysis of Survey Results (95% Confidence Interval Analysis)

184 pilots responded to the survey. The mean response ratings for each survey element are listed in the following pages. The means are given with a 95% confidence interval assuming a normal distribution of data. The standard deviations are also presented to give an indication of variability in individual responses.

PARTY LINE SURVEY RESULTS (n=184)

IMPORTANCE

		Mean ($\mu \pm 1.96\sigma/\sqrt{n}$)	Stdev σ
Ground Ops	a/c crossing active rwy	4.65 ± .10	0.69
	other a/c "hold short"	4.06 ± .16	1.09
	controller errors	4.01 ± .16	1.10
	routing to rwy	3.45 ± .17	1.15
	ground sequencing	3.27 ± .15	1.04
	next comm freq	2.60 ± .16	1.13
Departure	wx situation	4.40 ± .10	0.70
	ride reports	4.06 ± .12	0.84
	traffic watch	3.92 ± .15	1.07
	controller errors	3.91 ± .16	1.10
	next comm freq	2.90 ± .16	1.14
Cruise	wx situation	4.38 ± .10	0.68
	ride reports	4.10 ± .11	0.76
	controller errors	3.63 ± .17	1.17
	traffic watch	3.36 ± .17	1.17
	sequencing	3.04 ± .15	1.04
	winds aloft	2.85 ± .14	0.98
	next comm freq	2.70 ± .16	1.08
Descent	wx situation	4.41 ± .09	0.63
	hold situation/EFC	4.08 ± .13	0.88
	traffic watch	3.98 ± .15	1.01
	ride reports	3.97 ± .12	0.82
	controller errors	3.82 ± .16	1.11
	sequencing	3.48 ± .13	0.93
	next comm freq	3.08 ± .15	1.07
Terminal Area	wx situation	4.47 ± .09	0.61
	traffic watch	4.22 ± .13	0.91
	approach clearance	4.16 ± .13	0.91
	terminal routing	4.09 ± .12	0.81
	hold situation/EFC	4.01 ± .13	0.91
	controller errors	3.97 ± .16	1.13
	ride reports	3.86 ± .13	0.92
	sequencing	3.82 ± .12	0.85
	next comm freq	3.46 ± .17	1.15
Final Approach	windshear	4.87 ± .05	0.34
	a/c on your ldg rwy	4.81 ± .07	0.49
	braking action	4.63 ± .08	0.53
	missed approach - wx	4.61 ± .10	0.69
	wx situation	4.50 ± .12	0.83
	go around	4.32 ± .12	0.85
	traffic watch	4.09 ± .15	1.05
	sequencing	3.71 ± .15	1.06
	taxiway turnoff	3.46 ± .17	1.17
	next comm freq	3.26 ± .19	1.29

AVAILABILITY

		Mean ($\mu \pm 1.96\sigma/\sqrt{n}$)	Stdev σ
Ground Ops	a/c crossing active rwy	3.86 ± .16	1.10
	other a/c "hold short"	3.82 ± .14	0.94
	routing to rwy	3.81 ± .14	0.99
	next comm freq	3.75 ± .17	1.15
	ground sequencing	3.40 ± .15	1.05
	controller errors	2.96 ± .14	1.00
Departure	ride reports	3.86 ± .12	0.86
	wx situation	3.70 ± .13	0.90
	next comm freq	3.69 ± .15	1.03
	traffic watch	3.44 ± .14	0.95
	controller errors	2.81 ± .15	1.06
Cruise	ride reports	3.99 ± .12	0.80
	wx situation	3.86 ± .12	0.84
	next comm freq	3.76 ± .14	0.98
	traffic watch	3.24 ± .14	0.95
	sequencing	2.99 ± .15	1.05
	winds aloft	2.79 ± .14	0.94
	controller errors	2.74 ± .14	0.96
Descent	wx situation	3.83 ± .12	0.83
	hold situation/EFC	3.81 ± .12	0.86
	next comm freq	3.79 ± .13	0.93
	ride reports	3.77 ± .12	0.86
	traffic watch	3.44 ± .14	0.96
	sequencing	3.40 ± .13	0.91
	controller errors	2.94 ± .14	0.97
Terminal Area	approach clearance	4.07 ± .12	0.82
	next comm freq	3.96 ± .13	0.88
	wx situation	3.94 ± .11	0.79
	terminal routing	3.86 ± .13	0.90
	hold situation/EFC	3.77 ± .13	0.92
	traffic watch	3.69 ± .13	0.90
	ride reports	3.68 ± .13	0.91
	sequencing	3.48 ± .13	0.87
	controller errors	2.99 ± .14	1.00
Final Approach	wx situation	4.00 ± .13	0.91
	next comm freq	3.98 ± .14	0.97
	a/c on your ldg rwy	3.91 ± .14	0.96
	braking action	3.90 ± .13	0.92
	windshear	3.89 ± .14	0.95
	missed approach - wx	3.88 ± .14	0.95
	go around	3.83 ± .14	0.95
	traffic watch	3.67 ± .14	0.94
	sequencing	3.64 ± .13	0.91
	taxiway turnoff	3.25 ± .15	1.03

ACCURACY

		Mean ($\mu \pm 1.96\sigma/\sqrt{n}$)	Stdev σ
Ground Ops	a/c crossing active rwy	4.12 ± .13	0.88
	next comm freq	3.85 ± .14	0.97
	other a/c "hold short"	3.81 ± .13	0.90
	routing to rwy	3.64 ± .14	0.99
	ground sequencing	3.50 ± .14	0.99
	controller errors	3.26 ± .14	0.97
Departure	ride reports	3.74 ± .11	0.79
	wx situation	3.71 ± .12	0.82
	next comm freq	3.63 ± .16	1.09
	traffic watch	3.40 ± .14	0.95
	controller errors	3.00 ± .15	1.02
Cruise	wx situation	3.83 ± .12	0.81
	ride reports	3.81 ± .11	0.77
	next comm freq	3.77 ± .14	1.00
	traffic watch	3.45 ± .13	0.91
	winds aloft	3.42 ± .14	0.95
	sequencing	3.30 ± .15	1.04
	controller errors	2.97 ± .15	1.02
Descent	wx situation	3.89 ± .11	0.76
	ride reports	3.78 ± .11	0.75
	next comm freq	3.77 ± .14	0.98
	hold situation/EFC	3.67 ± .12	0.85
	sequencing	3.46 ± .12	0.83
	traffic watch	3.44 ± .12	0.86
	controller errors	3.06 ± .14	0.94
Terminal Area	approach clearance	4.09 ± .11	0.79
	next comm freq	4.00 ± .13	0.91
	wx situation	3.91 ± .11	0.78
	terminal routing	3.84 ± .11	0.77
	ride reports	3.73 ± .12	0.83
	hold situation/EFC	3.66 ± .12	0.86
	traffic watch	3.63 ± .13	0.87
	sequencing	3.62 ± .12	0.84
	controller errors	3.15 ± .14	0.98
Final Approach	a/c on your ldg rwy	4.12 ± .11	0.77
	next comm freq	4.09 ± .13	0.92
	wx situation	4.07 ± .12	0.83
	missed approach - wx	4.06 ± .12	0.86
	go around	4.02 ± .12	0.83
	braking action	3.91 ± .12	0.81
	windshear	3.84 ± .13	0.89
	traffic watch	3.79 ± .13	0.88
	sequencing	3.79 ± .13	0.87
	taxiway turnoff	3.38 ± .14	0.99

BY PHASE

		Mean ($\mu \pm 1.96\sigma/\sqrt{n}$)	Stdev σ
Importance	final approach	4.23 ± .08	0.57
	terminal area	4.01 ± .04	0.28
	departure	3.84 ± .08	0.56
	descent	3.83 ± .06	0.43
	ground ops	3.67 ± .10	0.72
	cruise	3.44 ± .09	0.63
Availability	final approach	3.79 ± .03	0.23
	terminal area	3.71 ± .05	0.33
	ground ops	3.60 ± .05	0.36
	descent	3.57 ± .05	0.33
	departure	3.50 ± .06	0.41
	cruise	3.34 ± .08	0.53
Accuracy	final approach	3.91 ± .03	0.22
	terminal area	3.74 ± .04	0.28
	ground ops	3.70 ± .04	0.30
	descent	3.58 ± .04	0.28
	cruise	3.51 ± .05	0.32
	departure	3.50 ± .04	0.31

ACROSS ALL PHASES

		Mean ($\mu \pm 1.96\sigma/\sqrt{n}$)	Stdev σ
Importance	wx situation	4.43 ± .01	0.05
	hold situation/EFC	4.04 ± .01	0.05
	ride reports	4.00 ± .01	0.10
	controller errors	3.87 ± .02	0.15
	traffic watch	3.87 ± .05	0.36
	sequencing	3.51 ± .05	0.35
	next comm freq	3.00 ± .05	0.33
Availability	wx situation	3.86 ± .02	0.11
	ride reports	3.83 ± .02	0.14
	next comm freq	3.82 ± .02	0.12
	hold situation/EFC	3.79 ± .00	0.03
	traffic watch	3.50 ± .03	0.19
	sequencing	3.38 ± .04	0.27
	controller errors	2.89 ± .01	0.10
Accuracy	wx situation	3.88 ± .02	0.13
	next comm freq	3.85 ± .02	0.17
	ride reports	3.76 ± .01	0.04
	hold situation/EFC	3.67 ± .00	0.00
	sequencing	3.54 ± .03	0.21
	traffic watch	3.48 ± .01	0.10
	controller errors	3.09 ± .02	0.12

MISCELLANEOUS

		Mean ($\mu \pm 1.96\sigma/\sqrt{n}$)	Stdev σ
Importance	call sign confusion	4.53 ± .11	0.74
	controller urgency	4.22 ± .12	0.85
	ATC prob/lost comm	4.22 ± .13	0.93
	navaid problems	3.96 ± .13	0.89
	other pilot urgency	3.83 ± .15	1.03
	sector congestion	3.70 ± .15	1.03
	controller exp level	3.43 ± .15	1.04
	bkgnd reassurance	3.31 ± .17	1.16
	other pilot exp level	3.08 ± .16	1.10
Availability	controller urgency	3.93 ± .14	0.99
	sector congestion	3.89 ± .14	0.98
	bkgnd reassurance	3.78 ± .15	1.07
	call sign confusion	3.71 ± .14	0.94
	other pilot urgency	3.60 ± .15	1.07
	controller exp level	3.49 ± .16	1.08
	ATC prob/lost comm	3.19 ± .15	1.04
	navaid problems	3.19 ± .15	1.02
	other pilot exp level	3.14 ± .17	1.16
Accuracy	controller urgency	3.73 ± .15	1.02
	bkgnd reassurance	3.71 ± .17	1.18
	sector congestion	3.61 ± .13	0.89
	navaid problems	3.59 ± .14	0.98
	call sign confusion	3.51 ± .15	1.04
	other pilot urgency	3.49 ± .15	1.03
	ATC prob/lost comm	3.40 ± .14	0.96
	controller exp level	3.06 ± .15	1.03
	other pilot exp level	2.78 ± .15	1.02

MISCELLANEOUS/BACKGROUND

	Mean ($\mu \pm 1.96\sigma/\sqrt{n}$)	Stdev σ
DL-PLI	3.03 ± .12	0.82
DL-PLI with compensation	2.71 ± .13	0.92
SHIFT (towards "DATALINK ONLY")	0.50 ± .12	0.81
TCAS (1=unfavorable...3=favorable)	2.18 ± .11	0.76
PDC (1=unfavorable...3=favorable)	2.83 ± .07	0.48
AGE	40.8	8.13
AA years	10.1	8.02
Total years	17.0	8.03
Flight experience (total hours)	8914	5027

	Total Number
Captains	86
First officers	77
Second officers	9
Military background	88
Non-military background	89
TCAS qualified	111
EFIS qualified	33
PC user	111

Appendix E:

Full-Mission Simulation Script

ADVANCED CONCEPTS FLIGHT SIMULATOR

Data Link/Party Line
Air Traffic Control

PHRASEOLOGY

Zulu +8

Los Angeles to San Francisco:

ATIS (LAX DEPARTURE)

1

This is the Los Angeles airport information XRAY 0045Z. Weather measured ceiling 1000 overcast, visibility 1 haze and smoke. Temperature 57 dewpoint 40 wind 260 at 10 altimeter 3002. Traffic landing and departing runways 24 and 25. Advise on initial contact you have Xray.

VENTURA 1 DEPARTURE, DIRECT VENTURA, DIRECT SAN MARCUS, DIRECT BIG SUR, DIRECT SAN FRANCISCO

After ACFS calls

2

LAX CLR: XXX is cleared as filed via the Ventura 1, maintain 5,000 expect flight level 310 three minutes after departure, departure control frequency will be 125.2 squawk 3647

After ACFS calls

3

LAX GND: XXX taxi runway 25L via Juliet, hold short of 25R

GROUND EVENT #1: Subject will encounter crossing traffic (UAL450)on taxiway. Ground control will make repeated calls to UAL450 telling him to hold for ACFS. UAL450 does not respond. Ground control will stop ACFS if necessary

LAX GND: United 450, hold short of the next taxiway for the United aircraft.

REPEAT ABOVE CALL SEVERAL TIMES

4

LAX GND: XXX, cross 25R contact the tower on 133.9

After ACFS calls

LAX TWR: King Air 56M hold short of 25L

N56M: roger, holding

5

LAX TWR: XXX, taxi into position and hold 25L

GROUND EVENT #2: After being cleared for takeoff, subject will hear the tower clear another aircraft to cross the runway farther downfield.

6

LAX TWR: XXX, wind 260 at 10, cleared for takeoff

LAX TWR: King Air 56M cross 25L, contact ground point 75

N56M: roger, 56M

when ACFS leaves 500'

7

LAX TWR: XXX contact departure control on 125.2

After ACFS calls

8

LAX DEP: XXX, departure control radar contact, climb and maintain 10,000

when ACFS is 20 miles west of LAX

9

LAX DEP: XXX, turn right heading 300, cleared direct Ventura, contact Los Angeles center on 135.5

After ACFS calls

10

LAX CTR: XXX roger, climb and maintain flight level 230, expedite through flight level 180

LAX CTR: TWA127 climb and maintain flight level 280

TWA127: roger up to 280, were out of nnn

LAX CTR: TWA127 contact the center on 135.3

TWA 127: 135.3, so long

after ACFS climbs out of flight level 200

11

LAX CTR: XXX, climb and maintain flight level 280, contact the center on 135.3

when ACFS approaches MQO

12

LAX CTR: XXX, contact Oakland center on 134.5

After ACFS calls

OAK CTR: XXX Oakland center, roger

ENROUTE EVENT: Approaching Zonal, subject will hear preceding aircraft give an unfavorable ride report (light to moderate turbulence) at the same altitude as subject.

TWA127: Ah center this is TWA127, we're getting bounced around here pretty good northwest of Zonal, we'd like to reduce to 280 kts.

OAK CTR: TWA127 roger

When ACFS is at ZONAL

13

OAK CTR: XXX, turn left heading 240 for spacing, maintain flight level 280, do not exceed 260 kts

when ACFS is 10 miles west of course

14

OAK CTR: XXX turn right heading 295

after 5 miles

15

OAK CTR: XXX, intercept J501, resume your own navigation *(this is a non intercept heading. If they do not question the clearance in 5 miles ask if they are going to start the turn or give them the right turn to 350)*

when ACFS is 30 south of Big Sur

16

OAK CTR: XXX, cleared to the San Francisco airport via the Big Sur arrival, contact the center on 128.7

After ACFS calls

17

OAK CTR: XXX roger, San Francisco altimeter is 30.04

18

OAK CTR: XXX traffic 11 o'clock 10 miles crossing left to right above you

19

OAK CTR: XXX traffic 1 o'clock 8 miles southeastbound, a Lear Jet below you.

ATIS (SFO ARRIVAL)

20

This is San Francisco airport information Delta 0145Z. Weather measured ceiling 300 overcast visibility 5. Temperature 50 dewpoint 41 wind light and variable altimeter 3004. Traffic landing runways 28 departing runways 1. Advise on initial contact you have Delta.

ARRIVAL DEVIATION EVENT: Subject is given an off route vector after BSR and a subsequent re-intercept.

When ACFS passes CARME

21

OAK CTR: XXX, turn left heading 270 vector for spacing maintain 16,000

22

OAK CTR: XXX traffic 12 o'clock 10 miles opposite direction below you

when ACFS is 15 miles west of course

23

OAK CTR: XXX, turn right heading 350 intercept the Oakland 151 radial and resume the Big Sur arrival, contact Bay approach on 133.9

After ACFS calls

24

BAY APP: XXX roger descend and maintain 6,000

25

BAY APP: XXX traffic 11 o'clock 10 miles eastbound above you

BAY APP: Mexicana 1248, advise prior to reducing below 250

26

BAY APP: XXX traffic 1 o'clock 10 miles southbound above you

27

BAY APP: XXX reduce to 210 knots contact Bay on 135.6

After ACFS calls

BAY APP: Mexicana 1248 your 10 miles from BRIJJ, turn left heading 310, maintain 2,000 until established on the localizer, cleared for ILS 28 right approach

28

BAY APP: XXX traffic 11 o'clock 5 miles east bound restricted below you

29

BAY APP: XXX turn right heading 350, descend and maintain 4,000, reduce to 180 knots

NOTE:

There are two other aircraft inbound to the airport - one from over CEDES, the other downwind north from over PYE

when ACFS is about 15 miles from airport

30

BAY APP: XXX is 10 miles from BRIJJ, turn left heading 300, maintain 2,000 until established on the localizer, cleared for ILS 28 right approach, maintain 160 knots until BRIJJ

SFO ARRIVAL EVENT: Subject is following a non-USA air carrier to runway 28R who is difficult to understand. This aircraft rolls out on the runway and is confused about which turnoff to take. After finally turning off the runway his landing gear collapses closing the airport. If the ACFS crew does not go around by 200 feet the tower will issue a go around. They are given a clearance to CROIT intersection to hold. Subject will eventually call company and will be sent to SMF.

when ACFS is 10 miles from airport

31

BAY APP: XXX contact the tower now

After ACFS calls

32

SFO TWR: XXX roger, reduce to approach speed, cleared to land 28 right

SFO TWR: Mexicana 1248 wind light and variable cleared to land 28 right

MEX1248: roger

Note:

The tower will make repeated calls to MEX1248 when he doesn't get off the runway - the pilot is confused as to which exit to take. Issue a go around to the ACFS ***ONLY*** if they don't go around on their own by 200 feet

33

SFO TWR: XXX go around, emergency in progress, maintain runway heading, climb and maintain 4,000 contact Bay Departure on 120.9

When ACFS is 5 miles west of SFO

34

BAY DEP: XXX roger, turn right heading 350, climb and maintain 5,000

35

BAY DEP: XXX on that heading intercept the SAU 035 radial cleared to CROIT intersection. Expect holding at CROIT

DAL427: Bay this is DAL427 checking in at 8,000 going to CROIT for holding

BAY DEP: DAL427 roger expect further clearance in 30 minutes

DAL427: roger

WWM1398: Bay this is Wings West1398 at 9,000 about to enter holding at CROIT

BAY DEP: Wings West 1398 roger, expect further clearance in 30 minutes

WWM1398: roger

36

BAY DEP: XXX, hold SW of CROIT on the SAU 035, right turns, climb and maintain 10,000 expect further clearance in 30 minutes

<u>HOLDING PATTERN EVENT #1:</u> While in the holding pattern, subject will hear approach control issue long, extended delays to aircraft below him.

SFO SPECIAL ATIS - *<u>READ TO THE NON-DATA LINK CREWS</u>*

37

This is San Francisco airport information Echo 0215Z. Weather measured ceiling 300 overcast visibility 5. Temperature 50 dewpoint 41 wind light and variable altimeter 3004. The airport is temporarily closed due to a disabled aircraft on the runway. Estimated time to re-opening is unknown.

<u>HOLDING PATTERN EVENT #2:</u> Subject overhears a VFR light aircraft call in at a position, heading and altitude that could be a confliction.

N387R: Bay this is Cessna 387R just departed the Sacramento VOR headed toward Sausalito at 9,500 requesting advisories

BAY DEP: Cessna 87R roger, be advised there is holding in progress on V150 from 10,000 and below, squawk 0421 and ident

BAY DEP: DAL427 now expect further clearance in 1 hour 30 minutes, request your intentions

DAL427: roger, stand by

BAY DEP: Wings West 1398, now expect further clearance in 1 hour 30 minutes, the airport is still closed

WWM1398: roger, we would like to go to Sacramento

ACFS will probably call company and get routed to SMF

3.8

COMPANY: Flight XXXX, be advised dispatch requests you divert to SMF. Contact dispatch with an estimate.

After ACFS calls

3.9

BAY DEP: XXX turn right heading nnn, Intercept V150 to Sacramento maintain 10,000

SIMILAR CALL SIGN EVENT: Subject is told of a civil jet on the frequency with a like sounding number.

BAY DEP: XXX be advised there is an American 727 on the frequency with the same number as you

BAY DEP: AALnnnn climb and maintain 11,000, contact Oakland Center on 124.2

AALnnnn: cleared to 11,000 and changing

4.0

BAY DEP: XXX contact Oakland Center on 124.2

After ACFS Calls

OAK CENTER: XXX Oakland Center at 10,000 roger

when ACFS is abeam CCR

4.1

OAK CENTER: XXX descend and maintain 7,000 contact Sacramento Approach on 125.6

ATIS (SMF ARRIVAL)

4.2

This is Sacramento Metropolitan airport information Alpha 0245Z. Weather clear visibility50 Temperature 58 dewpoint 39 wind 340 at 15 altimeter 3004. Runways 34 in use. Advise on initial contact you have Alpha.

When ACFS is 10-15 SW of SAC VOR

4.3

SAC APP: XXX roger fly heading nnn and intercept the 34 left localizer, descend and maintain 5,000, be advised there is a civil jet on the frequency with a similar number

4.4

SAC APP: XXX descend and maintain 3,000

when ACFS is 10 miles from airport

45

SAC APP: XXX n miles from LANEE, cleared for ILS 34 left approach, contact the tower at LANEE

After ACFS Calls

46

SMF TWR: XXX roger number 2 following a C5 eight miles ahead, caution wake turbulence

AMWAY32: AMWAY32 on the touch and go requesting another approach

SMF TWR: AMWAY32 roger, maintain runway heading, contact approach on 125.6

47

SMF TWR: XXX traffic 11 o'clock 4 miles southeast bound altitude unknown

48

SMF TWR: XXX wind 340 at 15, cleared to land 34 left

on rollout

49

SMF TWR: XXX turn right first available taxiway, contact ground on 121.7 clearing

After ACFS Calls

50

SMF GND: XXX roger taxi to gate

Sacramento to San Francisco:

ATIS (SMF DEPARTURE)

51

This is the Sacramento Metropolitan airport information Charlie 0045Z. Weather 2500 scattered visibility 10. Temperature 55 dewpoint 42 wind 160 at 10 altimeter 2996. Runways 16 in use. Advise on initial contact you have Charlie.

CLIMB VIA RUNWAY HEADING FOR RADAR VECTORS TO SACRAMENTO VOR, RISTI 2 ARRIVAL TO RUNWAYS 28 AT SAN FRANCISCO.

After ACFS Calls

52

SMF CLR: Cleared to San Francisco via runway heading vectors to SAC, RISTI 2 arrival, maintain 5,000 expect 11,000 three minutes after departure. Departure control frequency will be 125.2 squawk 4331

After ACFS Calls

5.3

SMF GND: XXX taxi to runway 16 right via the parallel

N17X: Ground, this is Gulfstream 17X for taxi

SMF GND: Gulfstream17X taxi to runway 16R via the parrallel

N17X: 17X roger

N17X: Tower this is Gulfstream 17X ready for takeoff

SMF TWR: Gulfstream 17X wind 170 at 10 cleared for takeoff

N17X: 17X's rolling

After ACFS Calls

5.4

SMF TWR: XXX taxi into position and hold

5.5

SMF TWR: XXX wind 160 at 10, cleared for takeoff

SMF TWR: 17X contact departure

N17X: 17X roger good day

when ACFS leaves 500'

5.6

SMF TWR: XXX contact departure on 125.2

After ACFS Calls

5.7

SAC DEP: XXX this is Sacramento departure radar contact, ammend your clearance cleared direct Manteca, then the RISTI 2 arrival, maintain 5,000

when ACFS is about 10 south of airport

5.8

SAC DEP: XXX traffic 2 o'clock 10 miles eastbound unverified altitude 5,500

5.9

SAC DEP: XXX Climb and maintain 9,000 contact Oakland center on 124.2

TRAFFIC EVENT: Traffic is exchanged between ACFS and VFR conflict. The second time only the VFR is told about traffic

After ACFS Calls

60

OAK CTR: XXX Oakland center roger climb and maintain 11,000

61

OAK CTR: XXX, Traffic 11 o'clock, 12 miles northwest bound, VFR at 9,500

OAK CTR: N42X, traffic 1 o'clock 11 miles southeast bound, a United jet at 9,000

N42X: roger were looking

OAK CTR: N42X previous traffic now a 2 o'clock 5 miles southeast bound

N42X: roger were still looking

ATIS (SFO ARRIVAL)

62

This is San Francisco airport information Golf 0045Z. Weather 3000 scattered visibility 50. Temperature 54 dewpoint 41 wind 210 at 5 altimeter 2996. Traffic landing runways 28 departing runways 1. Advise on initial contact you have Golf.

when ACFS is approaching CEDES

63

OAK CTR: XXX contact Bay approach on 134.5

WRONG INFORMATION EVENT: Subject is told he is on a vector for the wrong runway.

After ACFS Calls

BAY APP: DAL298 fly heading 280 for vectors to 29R

DAL298: Right to 280 for 29R

64

BAY APP: XXX fly heading 280 for vectors to 29R

After ACFS sees the error put them on a heading for CEDES

65

BAY APP: XXX bay approach, cross CEDES at 11,000 maintain 7,000 depart CEDES heading 240 and intercept the 28 right localizer

SIMILAR CALL SIGN EVENT: Subject is told of a civil jet on the frequency with a like sounding number.

BAY APP: XXX be advised there is a company aircraft on the frequency with a similar number

BAY APP: UAL105 descend and maintain 6,000

UAL105: roger, out of 10,000 for 6,000

BAY APP: UAL105 reduce to 200 knots, contact Bay on 121.3

UAL 105: reducing and going to 121.3

<u>when ACFS is abeam San Jose</u>

<u>66</u>

BAY APP: XXX descend and maintain 6,000, contact the Bay on 135.6

<u>After ACFS Calls</u>

<u>67</u>

BAY APP: XXX roger, descend and maintain 4,000, reduce to 180 knots

<u>when ACFS is 15 miles from airport</u>

<u>68</u>

BAY APP: XXX 10 miles from BRIJJ, cleared for ILS 28 right, reduce to and maintain 160 knots to BRIJJ contact tower at 10 DME.

<u>After ACFS Calls</u>

<u>69</u>

SFO TWR: XXX roger. wind 210 at 10 cleared to land 28R.

<u>on rollout</u>

<u>70</u>

SFO TWR: XXX turn left first available taxiway, cross 28 left contact ground 121.8 clearing

<u>After ACFS Calls</u>

<u>71</u>

SFO GND: XXX roger, taxi to gate

San Francisco to Los Angeles:

ATIS (SFO DEPARTURE)

<u>72</u>

This is San Francisco airport information Hotel 0145Z. Weather 3000 scattered visibility 50. Temperature 55 dewpoint 41 wind 200 at 5 altimeter 2996. Traffic landing and departing runways 28. Advise on initial contact you have Hotel.

PORTE 8 DEPARTURE, AVENAL TRANSITION, DIRECT FILMORE FILMORE 6 ARRIVAL (RUNWAY 24/25 PROFILE DESCENT) TO RUNWAYS 24/25 AT LOS ANGELES

After ACFS Calls

73

SFO CLR: XXX Cleared as filed via the Porte 8, maintain 11,000, expect flight level 290 10 minutes after departure. Departure control frequency will be 120.9 squawk 4115

After ACFS Calls

74

SFO GND: XXX taxi runway 28 right via the outer and foxtrot hold short of the 1's

75

SFO GND: XXX cross runways one contact tower on 120.5

76

SFO TWR: XXX Cross 28 left, taxi into position and hold 28 right

After ACFS Calls

77

SFO TWR: XXX wind 210 at 5, cleared for takeoff

after ACFS passes 500'

78

SFO TWR: XXX contact departure on 120.9

After ACFS Calls

79

BAY DEP: XXX Bay departure, radar contact

BAY DEP: United 689 contact Oakland center on 128.7

80

BAY DEP: XXX fly heading 180 vector for spacing

ASA311: Bay this is ASA311 off 28 right climbing to 11,000

BAY DEP: Alaska 311 Bay departure radar contact

81

BAY DEP: XXX turn left heading 060, intercept and resume the PORTE 8 departure, climb and maintain flight level 230, contact Oakland center on 128.7

After ACFS Calls

82

OAK CTR: XXX expect to cross Pesca at or above 16,000

Before ACFS reaches 14,000

3.3

OAK CTR: XXX Oakland center cross Pesca at or above 16,000 expedite through 18,000 traffic 1 o'clock 5 miles westbound altitude unknown

after ACFS passes 20,000

OAK CTR: UAL689 contact the center on 134.5

3.4

OAK CTR: XXX contact the center on 134.5

After ACFS Calls

3.5

OAK CTR XXX Climb and maintain flight level 290

3.6

OAK CTR: XXX traffic 10 o'clock 12 miles westbound below you

ASA311: Center Alaska 311 climbing out of nnn for flight level 230

OAK CTR: Alaska 311 roger, climb and maintain flight level 290

OAK CTR: United 689 ammend clearance, fly heading 140 receiving San Marcus proceed direct then via the SADDE 4 arrival to Los Angeles, maintain flight level 290

UAL689: United 689 roger direct San Marcus and the SADDE 4 arrival

After passing WAGES

3.7

OAK CTR: XXX, ammend clearance, fly heading 130 receiving San Marcus proceed direct then via the SADDE 4 arrival to Los Angeles, maintain flight level 290

OAK CTR: United 689 contact Los Angeles center on 135.3

When ACFS passes abeam Avenal

3.8

OAK CTR: XXX contact Los Angeles center on 135.3

After ACFS Calls

LAX CTR: XXX Los Angeles center, roger

ASA311: Center, Alaska 311 here at 310

LAX CTR: Alaska 311 Los Angeles center roger

LAX CTR: United 689 contact the center on 132.6

UAL689: United 689 roger

<u>19</u>

LAX CTR: XXX contact the center on 132.6

<u>After ACFS Calls</u>

<u>20</u>

LAX CTR: XXX cleared to LAX via the SADDE 4 arrival cross FIM at or below 190 maintain 150. Los Angeles altimeter 30.10

ASA311: Los Angeles Alaska 311 out of flight level 310 on the SADDE 4 arrival

LAX CTR: Alaska 311 roger Los Angeles altimeter nn.nn

<u>21</u>

This is the Los Angeles airport information yankee 0345Z. Weather clear visibility 50. Temperature 53 dewpoint 30 wind 310 at 20, peak gusts 25 altimeter 2993. Traffic landing and departing runways 24 and 25. Advise on initial contact you have Yankee.

<u>22</u>

LAX CTR: XXX contact Los Angeles Approach on 135.2 *(this is a test for the crew to respond to a wrong frequency. If the crew should become lost in the frequency spectrum, use the following message):*

<u>23</u>

LAX CTR: Advisory: Communications link failure, contact Los Angeles center on 132.6

ATIS (LAX ARRIVAL)

LAX CTR: United 689 contact Los Angeles approach on 124.5

UAL689: roger changing

<u>24</u>

LAX CTR: XXX reduce speed to 280 knots descend to cross Symon at 12000.

<u>25</u>

LAX CTR: XXX contact Los Angeles approach on 124.5

<u>After ACFS Calls</u>

LAX APP: XXX Los Angeles approach roger

ASA311: Approach, Alaska 311 out of nnn for nnn

LAX APP: Alaska 311 roger let me know when you have information xray

ASA311: roger, we have xray

96

LAX APP: XXX cross Bayst at 10000

SEQUENCING EVENT: Subject has been following and is being followed by the same aircraft for some time. Subject (and traffic) is vectored downwind north of LAX in a normal way. Subject hears lead aircraft, and subsequently the following aircraft turned to base leg and subject is not.

97

LAX APP XXX Depart SMO heading 070 descend and maintain 6000.

LAX APP: UAL689 turn right heading 160, descend and maintain 4,000

UAL689: roger right to 160 and we're out of nnn for 4,000

LAX APP: Alaska 311 turn right heading 160 for base leg, descend and maintain 4,000

ASA311: roger out of nnn for 4,000 heading 160

ACFS may ask for turn to base

98

LAX APP: XXX roger, *we had to vector you a little farther downwind for spacing*, turn right heading 160 for base leg, descend and maintain 4,000

LAX APP: UAL689 nn miles from LIMMA turn right heading 210 maintain nn until established on the localizer, cleared for ILS 25 right approach contact tower at LIMMA

UAL689: Cleared for approach

LAX APP: ASA311 nn miles from LIMMA turn right heading 210 maintain nn until established on the localizer, cleared for ILS 25 right approach contact tower at LIMMA

ASA311: roger

99

LAX APP: XXX nn miles from LIMMA turn right heading 210 maintain 3,500 until established on the localizer, cleared for ILS 25 right approach contact tower on 133.9 at LIMMA

After ACFS Calls

100

LAX TWR: XXX Los Angeles tower roger wind 310 at 20 cleared to land 25 right

WIND SHEAR EVENT: The ACFS will experience an airspeed loss of 15 knots on final. They may elect to go around.

UAL689: Ah tower we experienced a 15 knot loss at 500 ft.. you might want to warn other aircraft

LAX TWR: Roger, ASA311 did you copy that , the B727 ahead of you had a 15 knot loss on final

ASA311: This is ASA311 roger, we just experienced the loss, we're going around

LAX TWR: ASA311 roger, maintain runway heading, climb and maintain 3,000, contact approach on 124.5

ASA311: roger changing

101

LAX TWR: XXX be advised that two aircraft ahead of you experienced a fifteen knot loss on final, wind 310 at 22, cleared to land

If ACFS goes around

102

LAX TWR: XXX maintain runway heading, climb and maintain 3,000, contact approach on 124.5

After ACFS Calls

103

LAX DEP: XXX Los Angeles departure roger turn right heading 070 climb and maintain 4,000

When ACFS is 10 to 15 miles on downwind

104

LAX DEP: XXX turn right heading 160 descend and maintain 3,000

When ACFS approaches final

FOR 25 RIGHT

105

LAX DEP: XXX turn right heading 210, 7 miles form LIMMA, maintain 3,000 until established on the localizer, cleared for ILS 25 right approach, contact the tower on 133.9 at LIMMA

After ACFS Calls

106

LAX TWR: XXX Los Angeles tower roger wind 310 at 20 cleared to land 25 right

on rollout

FOR 24 RIGHT

107

LAX DEP: XXX turn right heading 210, 7 miles form ROMEN, maintain 3,000 until established on the localizer, cleared for ILS 24 right approach, contact the tower on 133.9 at ROMEN

After ACFS Calls

108

LAX TWR: XXX Los Angeles tower roger wind 310 at 20 cleared to land 24 right

109

LAX TWR: XXX turn right first available, contact ground on 121.7 clearing

110

LAX TWR: XXX turn left first available, contact ground on 121.7 clearing

After ACFS Calls

111

LAX GND: XXX roger taxi to gate

Appendix F:

Simulation PLI Event Analysis

Simulation PLI Event Analysis

For each crew and event a set of questions were invoked which paralleled the scoring criteria from 1 to 5 described in Chapter 4. The answers to each question was used as a *guideline* for determining the level of crew response to the PLI present from which the score for that event was derived.

PL1 Aircraft holding short at taxiway intersection	if "yes" then minimum score is at least
a. No indication of awareness.	1
b. Does the crew see or look for the other aircraft?	2-3
c. Is crew concerned that aircraft will hold short for them?	3-4
d. Does the crew query ATC concerning the traffic?	5
e. Does the crew stop the simulator?	5

The actual scores for all crew responses to PL1 based on this set of questions are summarized as follows.

Crew #	1	2	3	4	5	6	7
Score	2	2	5	5	1	2	3

These scores transfer to the summary of results in Table 4.2 as shown below.

Not Aware	Aware	Action Taken
1	4	2

PL2 Aircraft crossing active runway	if "yes" then minimum score is at least
a. No indication of awareness.	1
b. Does the crew hear about the other a/c?	2-3
c. Does the crew know he is crossing in front of them?	3-4
d. Does the crew query ATC about the traffic?	5
e. Does the crew abort the takeoff?	5

The actual scores for all crew responses to PL2 based on this set of questions are summarized as follows.

Crew #	1	2	3	4	5	6	7
Score	1	1	1	1	1	E	1

E = script error

These scores transfer to the summary of results in Table 4.2 as shown below.

Not Aware	Aware	Action Taken
6	0	0

PL3 Turbulence and Weather Deviations

	if "yes" then minimum score is at least
a. No indication of awareness.	1
b. Does the crew hear the other a/c report turbulence?	2
c. Does the crew know he is slowing?	3
d. Is the crew concerned about going thru turbulence?	4
e. Does the crew request a course or altitude deviation?	5

The actual scores for all crew responses to PL3 based on this set of questions are summarized as follows.

Crew #	1	2	3	4	5	6	7
Score	5	5	5	5	1	4	5

These scores transfer to the summary of results in Table 4.2 as shown below.

Not Aware	Aware	Action Taken
1	1	5

PL4 Aircraft on Runway of Intended Landing

	if "yes" then minimum score is at least
a. No indication of awareness.	1
b. Does the crew know the other a/c is on runway?	2-3
c. Does the crew state that they may have to go around?	3-4
d. Does the crew initiate a go around with ATC instructions?	4-5
e. Does the crew initiate a go around without ATC instructns?	5

The actual scores for all crew responses to PL4 based on this set of questions are summarized as follows.

Crew #	1	2	3	4	5	6	7
Score	4	2	4	4	4	4	4

These scores transfer to the summary of results in Table 4.2 as shown below.

Not Aware	Aware	Action Taken
0	7	0

PL5 Holding EFC Validity

	if "yes" then minimum score is at least
a. No indication of awareness.	1
b. Does the crew indicate hearing the other a/c's EFC?	2-3
c. Does this cause the crew to discuss diverting?	4
d. Does the crew decide to divert before the company calls?	5

The actual scores for all crew responses to PL5 based on this set of questions are summarized as follows.

Crew #	1	2	3	4	5	6	7
Score	5	5	5	5	5	2	5

These scores transfer to the summary of results in Table 4.2 as shown below.

Not Aware	Aware	Action Taken
0	1	6

PL6 Traffic watch in hold

	if "yes" then minimum score is at least
a. No indication of awareness.	1
b. Does the crew indicate hearing other aircraft?	2-3
c. Does this cause them to look for the traffic?	3-4
d. Does the crew discuss a possible conflict?	4
e. Does the crew query ATC about the traffic?	5
f. Does the crew modify the simulator flight path?	5

The actual scores for all crew responses to PL6 based on this set of questions are summarized as follows.

Crew #	1	2	3	4	5	6	7
Score	1	1	3	4	1	1	1

These scores transfer to the summary of results in Table 4.2 as shown below.

Not Aware	Aware	Action Taken
5	2	0

PL7 Traffic Watch During Climb

	if "yes" then minimum score is at least
a. No indication of awareness.	1
b. Does the crew hear traffic advisory given to other a/c?	2-3
c. Does crew see the traffic?	3-4
e. Does the crew modify the simulator flight path?	5

The actual scores for all crew responses to PL7 based on this set of questions are summarized as follows.

Crew #	1	2	3	4	5	6	7
Score	2	2	4	3	2	2	1

These scores transfer to the summary of results in Table 4.2 as shown below.

Not Aware	Aware	Action Taken
1	6	0

PL8 Aircraft Sequencing

	if "yes" then minimum score is at least
a. No indication of awareness.	1
b. Does the crew indicate knowing they are in a sequence?	2-3
c. Does the crew know the a/c ahead of them gets turned?	3-4
d. Does the crew know the a/c behind them gets turned?	3-4
e. Does the crew query ATC or request a turn?	5

The actual scores for all crew responses to PL8 based on this set of questions are summarized as follows.

Crew #	1	2	3	4	5	6	7
Score	2	2	2	M	1	3	2

M = missing data

These scores transfer to the summary of results in Table 4.2 as shown below.

Not Aware	Aware	Action Taken
1	5	0

PL9 Windshear on Final Approach

	if "yes" then minimum score is at least
a. No indication of awareness.	1
b. Does the crew hear other a/c report airspeed loss?	2-3
c. Does the crew query ATC for more info?	4-5
d. Does the crew adjust their approach speed?	5
e. Does the crew go around?	5

The actual scores for all crew responses to PL9 based on this set of questions are summarized as follows.

Crew #	1	2	3	4	5	6	7
Score	5	5	5	M	5	5	5

M = missing data

These scores transfer to the summary of results in Table 4.2 as shown below.

Not Aware	Aware	Action Taken
0	0	5