

## **'PARTY LINE' INFORMATION USE STUDIES AND IMPLICATIONS FOR ATC DATALINK COMMUNICATIONS**

R. John Hansman, Amy Pritchett & Alan Midkiff  
MIT International Center for Air Transportation  
MIT Aeronautical Systems Laboratory  
Room 33-113, 77 Mass. Ave  
Cambridge, MA 02139  
Tel: 617 253 2271  
Fax: 617 253 4196  
Email: rjhans@mit.edu

### **ABSTRACT**

The perceived importance and utilization of "party line" information by air carrier flight crews was investigated through pilot surveys and a flight simulation study. The Importance, Availability, and Accuracy of party line information elements were explored through surveys of pilots of several operational types. The survey identified numerous traffic and weather party line information elements which were considered important. These elements were scripted into a full-mission flight simulation which examined the utilization of party line information by studying subject responses to specific information element stimuli. The awareness of the different Party Line elements varied, and awareness was also affected by pilot workload. In addition, pilots were aware of some traffic information elements, but were reluctant to act on Party Line Information alone. Finally, 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 should be exercised when implementing datalink communications in tower and close-in terminal control sectors.

### **1. INTRODUCTION**

Current communications between aircraft and Air Traffic Control (ATC) use shared voice VHF frequencies. Aircraft on a common frequency can monitor all transmissions on that frequency. Some of the "party line" information (PLI) is used by pilots to increase their situation awareness with respect to other aircraft and environmental conditions.

However, several problems with voice communications have been identified. Although one study found a readback error rate of less than one percent [Cardosi 1993], such errors in communications have been found to contribute significantly to accidents and incidents. For example, problems in the transfer of information were noted in over 70% of the incident reports submitted to the Aviation Safety Reporting System (ASRS) over a five year period [Prinzo & Britton 1993]. These problems are compounded by the frequency congestion found in busy airspace sectors, and by high pilot and controller workload.

As part of the United States' Federal Aviation Administration's National Airspace System modernization plan, digital datalink communications will be introduced as a means of air/ground information exchange. The benefits of this new technology has been recognized by many sectors of the aviation community, and some datalink of information is already used for air transport aircraft, such as ACARS and the issuance of Pre-Departure Clearances via datalink at the gate [Phillips 1994] [RTCA 1986].

Several studies have already demonstrated the potential benefits of this type of communication. For example, controllers who participated in an evaluation of data link for the terminal area indicated that this technology has many potential benefits, including the reduction of frequency congestion, fewer communication errors, the ability to reliably transmit long and complex messages, and improved efficiency [Talotta 1992] [den Braven 1992]. Flight and simulation tests with pilots support these conclusions and also show a potential decrease in cockpit workload when the datalink information can be transferred into

the flight management system with a single button press, rather than by the pilot typing in clearances or setting values [Waller 1992] [Knox & Scanlon 1990].

However, given the discrete addressing of datalink communications, pilots would have reduced access to the information currently available from 'Party Line' Information. This loss of PLI would affect not only the aircraft equipped with datalink, but also the non-equipped aircraft, which then would not overhear PLI from any aircraft no longer making full use of the voice frequencies. Studies have suggested that the impact of PLI loss be examined, but at the time of these recommendations the extent to which pilots rely on PLI was not well understood [Knox & Scanlon 1990] [Benel 1991].

This paper will document the recent studies of PLI use and importance. First, the results of pilot surveys, documenting the importance, availability & accuracy of PLI, and issues about datalink implementation, will be documented. Then, the results of a piloted simulation will be detailed. Finally, the considerations that must be made in datalink implementation will be given.

## 2. PARTY LINE INFORMATION SURVEYS

In order to assess the use of PLI in the current ATC environment, specific input was solicited through a series of pilot opinion surveys. An initial survey was conducted of active transport category crews [Midkiff & Hansman, 1993]. A second survey investigated the differences in PLI utilization between different pilot operational domains (Air Transport, Commuter Airlines, General Aviation, Military) [Pritchett & Hansman 1994 & 1995].

### Survey Design

The surveys were each organized into three sections. The first gathered information about the respondents' characteristics and flight experience. The second section investigated issues related to datalink implementation; the final survey also solicited the information requirements for global situation awareness by asking the free response question "What does the 'Big Picture' mean to you?"

The final section of the surveys solicited pilot ratings of the importance, availability and accuracy of PLI for specific information elements, categorized into six phases of flight. The elements rated on five point scales, as shown in a sample from the survey in Figure 1.

	IMPORTANCE					AVAILABILITY					ACCURACY				
	Trivial		Critical			Non-Existent		Common-Place			Unreliable		Reliable		
<b>Departure:</b> <i>Takeoff to Top of Climb</i>	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Next Comm Frequency	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Traffic	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Error of Controller	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Relative Sequencing	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Weather - Thunderstorms	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Weather - Visibility & Ceiling	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5

Figure 1. Example of Survey Format (Departure Phase of Flight)

Using this system of ratings, a metric to display and illustrate the relative importance, availability and accuracy is the percentage of pilots giving a particular high or low rating. For example, in the case of the importance ratings, the importance of any element can be represented by the percentage of pilots giving it a Critical (5) rating, or the next highest rating (4), which is assumed to represent an Important Rating.

### Survey Results

For the sake of brevity, only the results from the final, more detailed survey are given here, unless otherwise noted. [Pritchett & Hansman 1994 & 1995]

**Overall Importance of PLI** The PLI elements in the survey were generally rated very highly. Across all the information elements given in the survey, a Critical (5) rating was given 42% of the time and the next highest Important (4) rating was given in an additional 28% of the responses.

**Importance Ratings by Phase of Flight** An overall comparison of the perceived variations of PLI importance between different Phases of Flight was made by comparing the combined ratings of all PLI elements listed within each. The highest ratings were given to the Phases of Flight nearest the airport, especially Terminal Area and Final Approach, where over 40% of the combined ratings were Critical. The lowest importance ratings are given in Cruise, where less than 30% of the ratings were Critical. These results are shown in Figure 2. The percentage of critical ratings for each successive Phase of Flight are significantly different from the one preceding ( $p < 0.01$ ), except between the ratings for Final Approach and Terminal Area.

In general, the individual weather and traffic PLI elements received importance ratings following the same pattern of higher importance ratings in the Terminal Area and Final Approach, and lower importance ratings in Cruise. However, some weather elements, such as *Thunderstorm Buildups and Deviations* were consistently perceived as important in all Phases of Flight. Other weather elements, such as *Winds Aloft*, received higher ratings in Cruise. This identifies very specific patterns of PLI use.

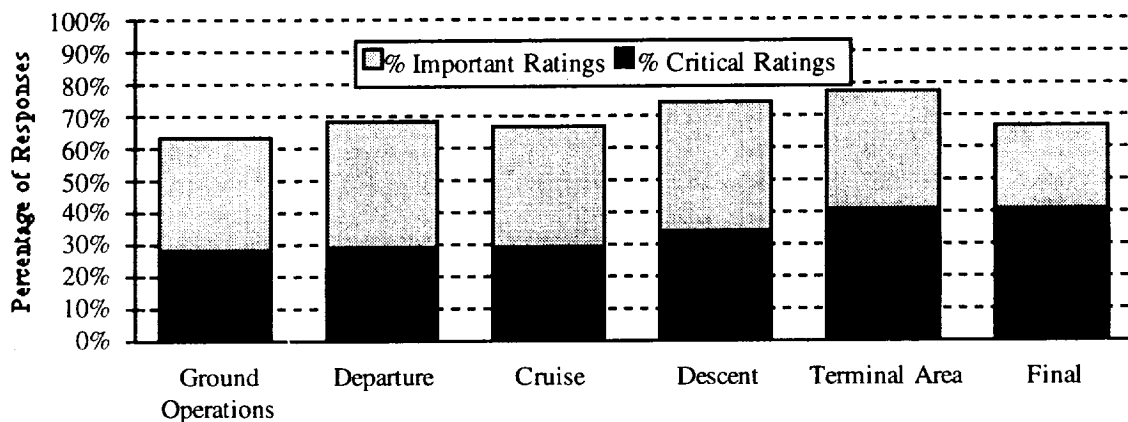


Figure 2. Percentage of Important (4) and Critical (5) Ratings Given to PLI Elements Within Each Phase of Flight

**Specific PLI Elements Rated Important or Critical** Many PLI elements were rated as Critical (5) or Important (at least 4) by a majority of the pilots for at least one Phase of Flight. These are listed in Table 1. The Critical elements tend to apply to traffic and weather situations which directly affect flight safety. Elements considered Important include the Traffic and Weather elements useful for flight planning. Some elements are considered Critical by a majority (greater than 50%) of pilots in some Phases of Flight and Important in others.

**Availability & Accuracy Ratings of PLI** Pilots generally did not give the extreme high or low values for the Availability and Accuracy ratings. Instead, these ratings indicated that pilots consider PLI generally reliable and accurate without giving any significantly higher ratings to any specific information elements.

The Availability and Accuracy ratings for the information elements were strongly correlated to each other, and to their corresponding Importance ratings. However, some PLI elements, *Next Communications Frequency, Controlled Traffic, Approach Clearance, Terminal Routing* and *Surface Winds*, were found to have high Availability and Accuracy ratings compared to their Importance ratings, possibly indicating their continuous presentation by Party Line communications.

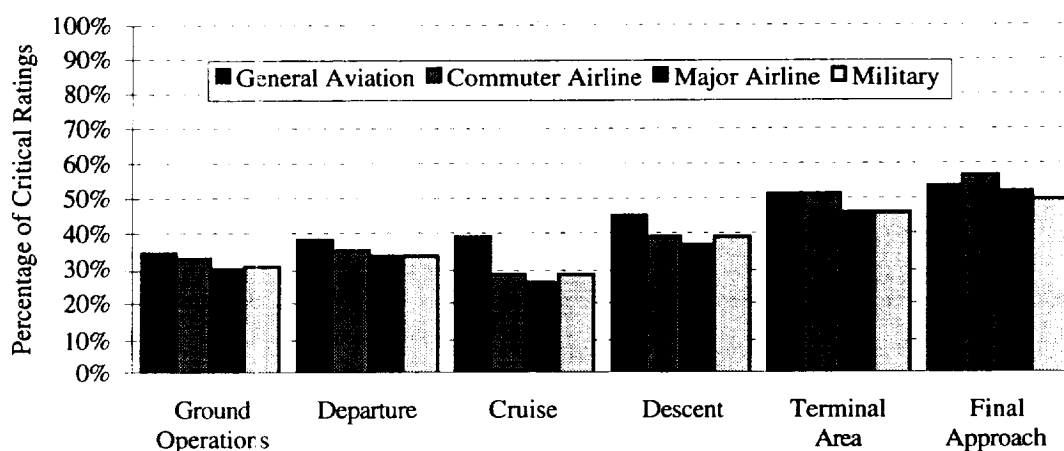
Conversely, the PLI elements *Error of Controller* and *Uncontrolled Traffic* were found to have disproportional low Availability and Accuracy ratings, possibly indicating that Party Line communications is not an adequate information source for these elements.

Information Elements Rated Critical (5)	Information Elements Rated Important (At Least 4)
<ul style="list-style-type: none"> <li>• Aircraft on Landing Runway (Final Approach)</li> <li>• Traffic - Uncontrolled Airports (Departure, Descent, Terminal Area &amp; Approach)</li> <li>• Traffic - Controlled Airports (Departure, Descent, Terminal Area &amp; Approach)</li> <li>• Traffic Avoidance (Cruise)</li> <li>• Windshear (Final Approach)</li> <li>• Missed Approach - Weather (Final Approach)</li> <li>• Visibility &amp; Ceiling (Terminal Area &amp; Final Approach)</li> <li>• Thunderstorms (All Phases of Flight)</li> <li>• Surface Winds (Final Approach)</li> <li>• Braking Action (Final Approach)</li> <li>• Icing Conditions (Departure, Descent &amp; Terminal Area)</li> <li>• Aircraft Crossing Active Runway (Ground Operations)</li> <li>• Approach Clearance (Terminal Area)</li> <li>• Terminal Routing (Terminal Area)</li> <li>• Missed Approach - Other (Final Approach)</li> <li>• Error of Controller (Ground Ops, Terminal Area &amp; Final Approach)</li> </ul>	<ul style="list-style-type: none"> <li>• Holding Situation/EFC Validity (Descent &amp; Terminal Area)</li> <li>• Relative Sequencing of Other Aircraft (All Phases of Flight)</li> <li>• "Hold Short" of Runway (Ground Operations)</li> <li>• Taxiway Turnoff (Final Approach)</li> <li>• Routing to (Take-Off) Runway (Ground Operations)</li> <li>• Weather Overall (All Phases of Flight)</li> <li>• Visibility &amp; Ceiling (Ground Operations, Departure &amp; Descent)</li> <li>• Ride Reports &amp; Turbulence (All Phases but Ground Operations)</li> <li>• Surface Winds (Ground Ops, Descent &amp; Terminal Area)</li> <li>• Icing Conditions (Ground Ops, Cruise &amp; Final Approach)</li> <li>• Error of Controller (Departure, Cruise &amp; Descent)</li> <li>• Next Communications Frequency (Descent, Terminal Area &amp; Final Approach)</li> </ul>

**Table 1. PLI Elements Rated Critical or Important by a Majority of Pilots**

***Variance in PLI Importance Between Pilots of Different Characteristics*** To study possible variations between importance ratings given by pilots from different operational types, the responses of General Aviation, Commuter Airline, Major Airline and Military pilots were compared. Several significant differences in perceived PLI importance were found.

First, General Aviation pilots rated PLI as consistently important in all Phases of Flight, without a significant drop in PLI importance during Cruise. This differs from the other pilots who perceive PLI to be more important in the busy Phases of Flight nearest the airport, as shown in Figure 3.



**Figure 3. PLI Importance Ratings During Different Phases of Flight of Pilots From Different Operations**

Second, certain PLI elements were rated significantly higher by specific groups of pilots. These results are summarized in Table 2.

Operational Type	Elements Rated Significantly Higher by This Type
General Aviation	Icing Conditions, Visibility & Ceiling, Winds Aloft, Relative Sequencing, Next Communication Frequency
Commuter Airline	Traffic Avoidance -- Uncontrolled Airports
Major Airline	Ride Reports & Turbulence, Routing to Runway, "Hold Short", Braking Action
Military	Traffic Avoidance -- Controlled Airports & (Cruise) Traffic Avoidance

**Table 2. Elements Perceived More Important by Pilots of Different Operational Types**

Attempts were made to isolate differences between pilots based on flight experience, as estimated by total flight hours. However, different experience levels corresponded closely with different types of operations -- for example, the Major Airline pilots had significantly more flight hours than any other group. Within the responses from each operational group, no differences could be found between pilots with different experience, suggesting that operational type is the strongest determinant in pilot perception of PLI importance.

**Information Requirements for Global Situation Awareness** To ascertain the information required for Global Situation Awareness, pilots were asked for free responses to the question "What does the 'Big Picture' mean to you?". Their responses were categorized and the percentage of responses in each tally are shown in Figure 4. Traffic is named significantly more often than any other information type ( $p < 0.01$ ); Weather is also cited significantly more often than any of the less mentioned items.

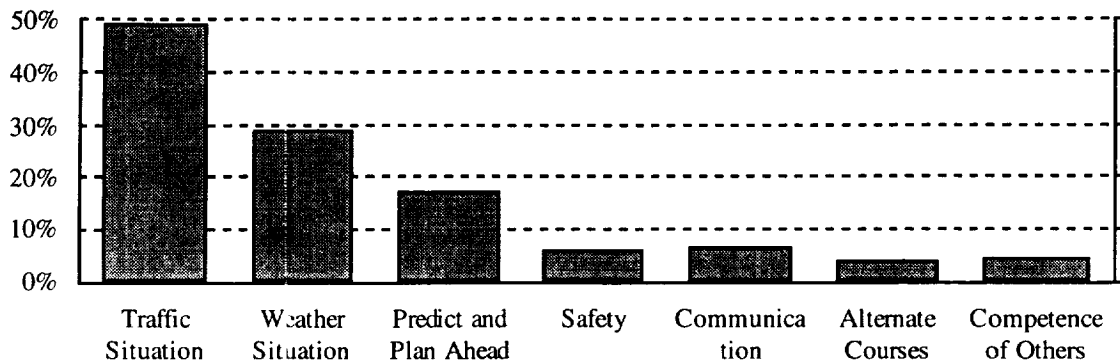


Figure 4. Percentage of Responses to "What does the 'Big Picture' mean to you?"

### 3. FLIGHT SIMULATION STUDIES

#### Simulation Overview

The results of the pilot opinion surveys indicated that many PLI elements are perceived as important by flight crewmembers. In order to study the usage of PLI during normal flight operations, a full-mission flight simulation experiment was developed. [Midkiff & Hansman 1993] Nine specific PLI elements, chosen by their high importance ratings on the survey, were scripted into the background ATC voice communications as stimuli. This experiment was conducted during voice communication flights which were the control phase of a "datalink" experiment conducted in the NASA-Ames Man-Vehicle Simulation Research Facility (MVS RF). Seven flight crews flew the experiment with PLI available.

The 'Party Line' communications were scripted in such a way as to require testable responses from the pilots. Each PLI event was analyzed to determine if the scripted PLI resulted in any change in crew awareness and if it elicited any action. This analysis was based on multiple sources, including: Observation notes; audio recordings; Video recordings; Switch & control positions; and Flight Path Data.

#### Simulation Results

The number of times that the flight crews were aware and/or took action based on each PLI element are shown in Table 3. The table lists the number of crews that were scored in each of the three categories of Not Aware, Aware (without an action taken), and Action Taken.

Pilots were the most aware of *Windshear*, *Holding/EFC Validity* and *Turbulence and Weather Deviations*, and they acted on these elements the most often. It was noted that the workload when these information elements were presented was low, and that the flight crew had the authority to take action without involving ATC.

Conversely, the lowest awareness was found for the elements *Aircraft Crossing the Active Runway* and *Traffic Watch While Holding*, which were presented during high workload situations.

Party Line Event	Not Aware	Aware No Action	Action Taken
<b>•Windshear on Final Approach</b> Subject is on final approach and the previous aircraft report large airspeed deviations due to windshear, with one of them going around	0	0	6
<b>•Holding/EFC Validity</b> Subject is in a holding pattern. Other aircraft holding below are given revised EFC's that, if projected to subject, would result in an unacceptable	0	1	6
<b>•Turbulence and Weather Deviations</b> Subject is near top of climb in trail of other aircraft. Preceding aircraft report turbulence ahead at subjects assigned altitude.	1	1	5
<b>•Aircraft Holding Short at Taxiway Intersect</b> ..Subject is approaching a taxiway intersection. Other aircraft does not acknowledge an instruction to hold short and continues towards it	1	4	2
<b>•Aircraft on Runway of Intended Landing</b> Subject is #2 for landing. Aircraft ahead is unable to clear runway in a timely manner, such that when a go-around is required	0	7	0
<b>•Traffic Watch During Climb</b> Subject is climbing out on departure. ATC issues traffic advisory (referring to subject) to crossing aircraft ahead. The crossing traffic replies "no	1	6	0
<b>•Aircraft Sequencing</b> Subject is in a line of aircraft being vectored around a rectangular landing pattern. Controller fails to turn the subject onto base but does turn the aircraft	1	5	0
<b>•Traffic Watch While Holding</b> Subject is holding. A "pop-up" VFR light aircraft checks in at 9500' and is told by ATC that, on its current course, it will "violate holding airspace"	5	2	0
<b>•Aircraft Crossing Active Runway While Subject is Lined Up for Take-Off</b>	6	0	0

**Table 3. Pilot Recognition of PLI Events**

The ability of flight crewmembers to assimilate PLI appears to be a function of workload and time available. There appears to be greater PLI assimilation utilization for low-workload conditions and low PLI assimilation in short-term high-workload situations. This implies that PLI is not a good transmission modality for important information.

The traffic-related events elicited very low action responses, which may be caused by several factors. First, the professional relationship dynamics between flight crewmembers and air traffic controllers may be a reason pilots were observed to be reticent to insinuate that a controller error had taken place based upon PLI alone, but instead indicated awareness and increased their vigilance. Second, an incorrect interpretation of PLI in traffic-related cases has a high perceived penalty that tended to prevent crews from taking action. Finally, because the simulator facility was not equipped with TCAS, the flight crews may have lacked sufficient global situation awareness to feel confident of their mental model as formed by PLI.

With the recent advances in cockpit displays and the increased information exchange possible with datalink communications, many possibilities exist for displaying this information graphically, for pilot selection of desired information, and for storing of information until the pilot has the time to consider it. The implementation of TCAS and the availability of better weather displays may enhance PLI use and help compensate for its loss in the datalink environment. For example, a study using TCAS for closely spaced parallel approaches has demonstrated pilot use of a traffic display to anticipate potential collisions [Pritchett & Hansman In Progress]. Little is known about these display effects, suggesting further studies.

## 4. CONCLUSIONS

Based on the survey and simulator study results, the following conclusions can be made:

- The PLI available from current voice communications provides pilots with information they perceive to be important. Consequently, care must be taken during datalink implementation for presenting pilots of both datalink equipped and non-equipped aircraft with sufficient information currently available from the 'Party Line' effect.
- Specific Traffic and Weather information elements have consistently been rated in pilot surveys as Critical. These results, combined with the citing of these two types of information as necessary for the 'Big Picture', suggest Traffic and Weather information is required for pilot Global Situation Awareness
- The importance of PLI was found to be significantly higher in the busier and higher density Phases of Flight near the airport, suggesting any initial implementation of datalink communications in the Terminal Area control sectors will require especial care to compensate for PLI loss.
- Although PLI is considered important by the pilots surveyed, the flight simulation studies show that the task of monitoring the voice frequencies for this PLI is not continued during some high workload conditions. PLI appeared to be used more for strategic decision making in low workload conditions.
- The flight simulation study also showed that pilots were sometimes aware of PLI but did not find it compelling enough to act upon. This was thought to be pilot reticence to assume a controller error had taken place without corroborating information from other sources.
- In summary, PLI appears to be an important but not always compelling source of Global Situation Awareness.
- Datalink implementation can be considered an opportunity to present the information currently available by Party Line communications in a more reliable, available and intuitive manner. Carefully designed datalink systems and procedures should be considered for their ability to provide pilot global situation awareness in order to support new methods of airspace management such as ADS and Free Flight.

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