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INTEGRATING SAFETY IN THE AVIATION SYSTEM: INTERDEPARTMENTAL TRAINING FOR PILOTS AND MAINTENANCE TECHNICIANS

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ABSTRACT

The study of human factors has had a decisive impact on the aviation industry. However, the entire aviation system often is not considered in researching, training, and evaluating human factors issues especially with regard to safety. In both conceptual and practical terms, we argue for the proactive management of human error from both an *individual* and *organizational* systems perspective. The results of a multidisciplinary research project incorporating survey data from professional pilots and maintenance technicians and an exploratory study integrating students from relevant disciplines are reported. Survey findings suggest that latent safety errors may occur during the maintenance discrepancy reporting process because pilots and maintenance technicians do not effectively interact with one another. The importance of interdepartmental or cross-disciplinary training for decreasing these errors and increasing safety is discussed as a primary implication.

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In the current aviation environment there is a strong emphasis on human factors issues in the improvement of aviation safety (Harle, 1994). Too often, however, this emphasis has not encompassed the entire aviation system in researching, training, and evaluating human factors practices. Traditionally, the study of aviation human factors has focused on understanding the mechanisms of *individual* human error so that measures to minimize the possibility of error could be devised. More recently, an alternative approach has been proposed that emphasizes the proactive management of human error from an *organizational* systems perspective (Maurino, Reason, Johnston, & Lee, 1995). Graham and Kuenzi (1997) also suggest a systems approach of combining methods to analyze human error. In addition to a reduction in risk of future errors, another positive by-product of this approach is increased communication between the various departments or career fields of the company (e.g., maintenance, flights operations, in-flight, and ground operations). This article argues for the adoption of a systems perspective in both conceptual and practical terms. It begins with a review of traditional human factors literature and discusses a contemporary shift toward systems thinking about error management. This viewpoint became the foundation for a multidisciplinary research project that addressed maintenance discrepancy reporting and incorporated survey data from pilots and maintenance technicians representing five industry segments and an exploratory study integrating students from relevant disciplines. Although somewhat limited by sample size and survey design, the implications of this study recommend interdepartmental training as a way to decrease errors and increase safety in the aviation system.

TRADITIONAL HUMAN FACTORS RESEARCH

Historically, the study of human factors and the application of related research findings have not encompassed the entire aviation system (Federal Aviation Administration, 2000). The goal of traditional human factors research has been to minimize human error in order to maximize system performance (Proctor & Van Zandt, 1994). Consequently, early research was based upon the popular, although incomplete, notion that aircraft accidents were attributable to individual pilot error thus affixing blame by inferring that human fallibility promoted poor decision making (Hawkins, 1987). While this seemed to appease public sensibilities (and bolster media sales), little was accomplished to evaluate root causes of mishaps or find ways of improving the system. In the early years of accident investigation, there was a tendency to cite blame primarily with the pilot (or air traffic controller) who was directly involved in the accident (Hawkins, 1987, p. 31; National Transportation Safety Board, 1987). The emphasis on pilot tasks overshadowed consideration of more mundane, lower-profile tasks such as airplane maintenance and passenger service. By narrowly focusing human factors research, training, and practice on the highest profile members of the intricate aviation system, the important interconnections of other key members and groups were virtually ignored.

SHIFT FROM INDIVIDUAL TO ORGANIZATIONAL SYSTEMS PERSPECTIVE

More recently, however, accident investigation has expanded its approach to consider the organization more broadly including the events leading up to the accident. In other words, what organizational factors (i.e., latent errors) led the individual to perform in such a way that his or her actions led to an accident (i.e., active error)? A major challenge to accident investigators is the analysis of factors that may have caused a chain of events reverberating all the way through the organization to the individual. Thus, a theoretical framework of error management must be general enough to encompass the organizational system and yet specific enough to be applicable to past and future accidents (Drury, Wenner, & Murthy, 1997; Maurino, et al., 1995).

Reason (1996) describes errors of two kinds. *Active errors* are those errors that are felt almost immediately. *Latent errors* are those errors that remain dormant for a long period of time but may surface much later, sometimes having significant consequences. It is easier for accident investigators to find the active errors while it is much more difficult to identify latent errors that may have occurred months or even years earlier. All levels of the aviation system contain complex levels of latent deficiencies. It is critical that aviation human factors specialists look beyond the individual to the larger organizational systems that affect the way individuals make decisions.

As in most bureaucracies, major decisions in the aviation environment are often made at the higher management levels (Parsons, 1951; Weber, 1947). These decisions affect all other levels of operation in the organization including personnel decisions, types of aircraft, software and manuals purchased, operating rules for flight crews and ground workers, safety requirements, and communication structures between departments (Westrum, 1996). Separated by time, space, or organizational linkages, these decision makers define the working environment that will strongly impact employee performance. Therefore, it is imperative that the broader issues of organizational contexts and interdepartmental issues be examined for their impact on the behavior of front-line employees (e.g., pilots and maintenance technicians).

As human factors models have evolved through aircraft accident and incident analysis, different segments of the industry have been added in a somewhat piecemeal fashion. Crew Resource Management (CRM) training emerged as a way to begin correcting some of the previous shortcomings. Pilot—aircraft, pilot—pilot, pilot—air traffic controller, and now pilot—automated aircraft interfaces have been developed (Edwards & Edwards, 1990; Hawkins, 1987; Helmreich, Merritt, & Willhelm, 1999). Federal Aviation Administration (1998) Advisory Circular 120-51C suggested that other groups, besides pilots, also be included in company training. These groups could include air traffic controllers, maintenance personnel, passenger service agents, mid-level and upper-level managers, airport operations, and special crisis teams (Bradley, 1995; Ewell & Chidester, 1996). Increasingly, many airlines subsume CRM training within general human factors and safety training. Arguably, emerging human factors research and training *have* reduced errors even though they have narrowly focused on *individual* roles rather than the *organizational* interconnections that occur between these individuals. By shifting to an organizational systems framework of error management, both conceptually and practically, an even greater impact on safety may result (Graham & Kuenzi, 1997; Maurino et al., 1995).

With this concept in mind, Purdue University researchers were interested in learning whether interdepartmental/interdisciplinary interaction among aviation personnel could positively influence working relationships and impact safety. To address this question, faculty and students from relevant disciplines worked together on a research project designed to survey pilots and maintenance technicians from various aviation organizations about their policies and practices for maintenance discrepancy reporting. In addition, students involved in the research project were surveyed about their perceptions of the importance and effectiveness of working with students from other disciplines to learn and complete a task.

METHOD

Survey Development: Interdisciplinary Student Research Teams

Graduate and undergraduate students from the disciplines of aviation technology, aviation flight, aviation administration, communication, and industrial organizational psychology were recruited for this study through professors in these departments and by word-of-mouth. Each student was assigned to one of five research teams. Each research team worked with a different type of aviation organization including regional, general aviation, corporate, and military operations. The research teams were comprised of students representing each discipline. A faculty member from one of the disciplines provided oversight for each research team. The goal of the research team was to work on the development of a survey both independently as a team and interdependently with the other research teams and with industry professionals. The goal of the survey was to solicit the opinions of professional pilots and maintenance technicians about the effectiveness of the procedures used in communicating maintenance discrepancy information in pilot write-ups or pilot squawks.

Industry Survey

Development of the industry survey of maintenance discrepancy reporting policies and practices occurred in four phases. First, each research team developed potential survey questions. Second, collaboration occurred across teams and with faculty to construct a preliminary survey that integrated the ideas of each research team. Third, industry representatives from each type of aviation organization were contacted for assistance. In addition, each research team visited at least one aviation organization and interviewed members of that organization to solicit feedback on the preliminary survey. These industry representatives and organizations were chosen by convenience based on prior contacts with or proximity to the university. After discussions with industry professionals, some questions were deleted, added, or modified. Fourth, the entire research team met to integrate the findings from the organizational interviews and finalize the survey.

Two versions of the survey were developed; one for pilots (see Appendix A) and one for maintenance technicians (see Appendix B). Virtually the same questions appeared on both surveys. The survey contained 23 questions, measured on a 7-point Likert scale, and a *not applicable/don't know* option. For example, one question posed the statement "Current methods of maintenance discrepancy reporting need improvement" and asked respondents to indicate their response to this statement with 1 being *strongly disagree*, 4 being *somewhat agree*, and 7 being *strongly agree*. In addition, open-ended and closed-ended questions were asked to gather demographics and information about company training and procedures in maintenance discrepancy reporting. For example, a close-ended, yes or no, question asked, "A class including both pilots and mechanics, based on communication and/or crew resource management, would be beneficial to the work environment?" Respondents were then asked in an open-ended fashion "Why or why not?" Blank lines were provided to write in their own words a rationale for their responses.

A comprehensive list of aviation organizations was generated including regional airlines, general aviation, corporate arrangements, and military operations. A total of 1,250 surveys were distributed to a random sample of pilots and maintenance technicians from the organization list either by mail or personal delivery. Two hundred twenty-two pilots and maintenance technicians completed and returned the survey for a response rate of 18 percent. The respondents represented 55 organizations. Pilots filled out 129 (58.1 percent) surveys and 93 (41.9 percent) surveys were filled out by maintenance technicians. This sample of responses was considered representative of aviation industry pilots and maintenance technicians because the individuals who completed this survey were randomly chosen.

Interdisciplinary Student Research Team Survey

Students participating in the research project were surveyed at the beginning (i.e., pre-test) and conclusion (i.e., post-test) of the research project (see Appendix C). A total of 50 pre-test and post-test student surveys were collected. Due to attrition, not all students who participated in the research project completed both surveys. These surveys contained 29 questions. Open-ended and close-ended response formats were used to collect demographic information, perceptions about students from other disciplines, and perceptions about working on the research project. On the pre-test and post-test, respondents were asked to indicate their perceptions of the various positions associated with aviation and represented on the student research teams (i.e., maintenance technician, pilot, communication specialist, aviation management). Issues addressed included "thinks like me," "status different from mine" and "background similar to mine." The response set was a 7-point Likert scale format with 1 indicating a *strongly disagree* response and 7 indicating a *strongly agree* response. On the post-test, respondents also were asked to indicate their general level of satisfaction with participating in the research project with 1 being *very dissatisfied* and 7 being *very satisfied*. In addition, they were asked about the advantages and disadvantages of working on the research project in an open-ended, free-response format.

RESULTS

Analysis of the survey results for pilots, maintenance technicians, and students provided insight into the question of whether interdepartmental/interdisciplinary interaction among aviation personnel would positively influence working relationships and impact safety. The results of the industry survey regarding maintenance discrepancy reporting are presented first, followed by the results of the interdisciplinary student research team survey.

Industry Survey

The industry survey was designed to assess current industry policies for reporting airplane maintenance discrepancies and inquired about respondents' perceptions of training regarding these policies. First, participants were queried about organizational policy for reporting airplane maintenance discrepancies between pilots and maintenance technicians. Respondents were given a number of choices (e.g., written logbook entry, face-to-face reporting, etc.) and an "other" option with blank lines to write in other policies. Most respondents reported that their organization's "policy for reporting maintenance discrepancies from pilots was a written logbook entry" (n=202, 91 percent) and/or an "electronic logbook entry" (n=33, 15 percent). Often, this policy included "face-to-face reporting" (n=130, 58.6 percent) which was the second most frequently reported policy.

Second, it was important to determine whether respondents thought their organization's policy was consistently followed and was considered effective. While both pilots (n=129, M=6.00) and maintenance technicians (n=93, M=5.97) thought their policy was consistently followed and was minimally effective (pilots n=128, M=5.88, maintenance technicians n=93, M=5.78), both groups saw several flaws in their organization's maintenance discrepancy reporting system. Of the 136 respondents to the open-ended question "Which part(s) of your company's policy for reporting maintenance discrepancies from pilots does not work well?," 43 (31.6 percent) wrote that the face-to-face aspect of the policy was not working well. Sixty-three respondents (46.3 percent) wrote that some aspect of the written or electronic logbook entries was problematic (e.g., lack of detail in write-up, not writing up discrepancy, ACARS codes are vague). There were no significant differences in the responses reported by pilots and maintenance technicians.

Third, it would be helpful to know if those using the maintenance discrepancy reporting system thought it needed to be improved. Both pilots and maintenance technicians (n=220) *somewhat agreed* that their organization's current method of maintenance discrepancy reporting needed improvement (M=3.72). Again, there were no significant differences in pilots' (n=128, M=3.69) and maintenance technicians' (n=92, M=3.76) responses to this question.

Finally, it was essential to examine the training pilots and maintenance technicians received regarding maintenance discrepancy reporting. To address the training issue, respondents were asked if they thought the "training/instruction regarding the entire maintenance reporting system" had been adequate. Together, pilots and maintenance technicians reported that their training had been *somewhat adequate* (n=228, M=4.73). There was no significant difference in pilots' (n=128; M=4.77) and maintenance technicians' (n=90, M=4.68) response to this question.

Further, respondents were asked if they thought that a "standardized debriefing or interview process, to supplement the written data, would help minimize miscommunication during maintenance discrepancy reporting." Pilots and maintenance technicians agreed with this statement (n=218, M=5.23). There was no significant difference in pilots' (n=126, M=5.25) and maintenance technicians' (n=92, M=5.21) responses.

Finally, to address their concern and interest in training, respondents were asked if they thought that "a class including both pilots and maintenance technicians, based on communication and/or crew resource management, would be beneficial." Of the 216 pilots and maintenance technicians who responded to this question, 179 (82.9 percent) thought that training integrating both groups would be beneficial. Thirty-seven respondents (17.1 percent) did not think joint training would be beneficial. Again, there was not a significant difference in the number of pilots or maintenance technicians who responded either in the affirmative or negative to this question. However, there was a significant difference in the overall number of pilots and maintenance technicians who thought interdepartmental training would be beneficial (n=218, $p<.05$).

Also, as noted in Table 1 and Table 2, there were a number of significant correlations between the policy and training issues of interest in this study. For both pilots and maintenance technicians, there was a significant positive correlation between their perceptions of the effectiveness of communication between the two groups and their perception of effectiveness of the maintenance discrepancy reporting policy. That is, increased perception of the effectiveness of communication was related to an increase in their perception of the effectiveness of the policy.

There was a significant positive correlation between their perceptions of whether the policy regarding maintenance discrepancy reporting was being followed and whether it was an effective policy and their perceptions of the adequacy of organizational training about maintenance discrepancy reporting. In other words, as their perceptions about policy adherence increased, there was a corresponding increase in their perceptions regarding policy effectiveness.

Significant negative, or inverse correlations were found between pilots and maintenance technicians perceptions of whether or not the policy was being followed and was effective and whether they perceived that the maintenance reporting system needed to be improved. That is, as perceptions that the policy was being followed and was effective increased,

Table 1. Correlation between perceptions of maintenance discrepancy reporting policy effectiveness and compliance and training issues for pilots

	Follow Policy	*Effective Policy*
Effective Communication	.401**	.419**
Adequate Training	.347**	.440**
System Needs Improvement	–.293**	–.470**

n=129
** $p < .01$; * $p < .05$

Table 2. Correlation between perceptions of maintenance discrepancy reporting policy effectiveness and compliance and training issues for maintenance technicians

	Follow Policy	*Effective Policy*
Effective Communication	.153	.509**
Adequate Training	.495**	.449**
System Needs Improvement	–.239*	–.382**

n=93
** $p < .01$; * $p < .05$

there was an associated decrease in their perceptions that the maintenance reporting system needed improvement.

The only correlation that was not consistently significant across the pilot and maintenance technician groups was between their perceptions of the effectiveness of communication and whether the policy was being followed. While there was a significant positive correlation between these perceptions for pilots, the relationship for maintenance technicians was not significant. In other words, as pilots' perceptions of the effectiveness of the communication between pilots and maintenance technicians increased, there was a related increase in their perceptions that the maintenance discrepancy reporting policy was being followed. For maintenance technicians, this relationship was not statistically significant.

Interdisciplinary Student Research Team Survey

After working together on the interdisciplinary research project there appeared to be some marked differences in student perceptions of students from other disciplines. Due to the small sample size (n=50; 30 pre-test, 20 post-test), only descriptive statistics are reported for the student survey and these statistics should be interpreted with caution. On the post-test, students generally perceived themselves as more similar to students from the other disciplines in their thinking (pre-test n=30, M=4.90, post-test n=20, M=5.06), behavior (pre-test n=30, M=3.83, post-test n=20, M=3.90), and social class (pre-test n=30, M=3.76, post-test n=20 M=4.0). The only area on the post-test that students perceived themselves as more different from one another after working together was in their background (pre-test n=30, M=4.43, post-test n=20, M=4.23).

After collaborating on the research project, all students were able to quickly list the responsibilities and tasks of students from the other disciplines. On the pre-test (n=30), for example, many students (n=27) had to leave one or more responses blank when asked to list the responsibilities and tasks involved in a typical day of students studying in the other disciplines. On the post-test (n=21), however, significantly fewer students (n=3) were unable to list any responsibilities or tasks of students from the other disciplines.

By having students catalog, in their own words, the advantages and disadvantages of participation in the research project, insight was also gained into students' (n=21) perceptions of training together on interdisciplinary teams. The most common advantage noted by the students was "learning to work with other disciplines" (n=10). Some students (n=7) also cited the "experiential nature of the project" as an advantage. The only advantage noted more often (n=8) was "making contacts/networking within industry." The most often cited disadvantage of working on the project was the unexpected amount of time the project involved (n=7).

Overall, on a scale of 1 (*very dissatisfied*) to 7 (*very satisfied*), students (n=21) reported a mean satisfaction level of 5.52 after participating in the research project. And one-third of the students (n=7) reported that satisfaction with their choice of major went up as a result of working on the project because they were exposed to industry and had an opportunity to apply the skills they had learned in school. The other two-thirds (n=14) of the students reported that their satisfaction with their major stayed the same after working on the project. None of the students reported that their satisfaction with their major decreased after working on the project.

IMPLICATIONS

This research has both conceptual and practical implications. The aviation industry representatives who completed the survey confirmed suspicions that during maintenance discrepancy reporting the potential for latent safety errors exists because pilots and maintenance technicians do not effectively interact with one another about maintenance problems on the airplane. Additionally, respondents, who themselves are members of a problematic organizational system, were asked to offer practical, proactive solutions for addressing inherent safety issues within that system. Results of both the industry survey and the interdisciplinary student research team survey suggest some viable training implications that may aid in decreasing errors and improving aviation safety.

For pilots and maintenance technicians who perceived problems in their current maintenance discrepancy reporting policy, it was agreed that organizational training may not have been adequate and that interdepartmental training may be beneficial. In fact, the reasons suggested by pilots and maintenance technicians for why an integrated training course on maintenance discrepancy reporting would be beneficial matched the reported advantages of working on an interdisciplinary research project reported by the students. The following paired reasons serve as examples. "Job awareness" was a reason reported by pilots and maintenance technicians and "awareness of the others' job" was reported by students. The need to "break down the wall of mistrust/conflict/close-mindedness" between the professions was reported by the pilots and maintenance technicians and "get to know students I wouldn't otherwise associate with" was reported by students. Students reported the importance of "experiential learning" and pilots and maintenance technicians reported "need more hands-on systems knowledge." Many pilots, maintenance technicians, and students noted that "stressing the importance of good communication" is achieved through integrated interactions. Also, some pilots and maintenance technicians thought that a joint class would help reinforce the joint goal of "striving toward being safe and on time." Based on the comments and suggestions provided by pilots, maintenance technicians, and students, it seems evident that integrating interdepartmental training may be a viable approach toward decreasing errors. Interestingly, many pilots, maintenance technicians, and students cited the same major obstacles to organized interdepartmental interaction or training—time and scheduling. Overcoming these and other logistical obstacles are necessary considerations in the development of organizational systems training.

Additionally, the experience and responses of students who worked on this research project seem to confirm the significance of interdisciplinary training for increasing systems awareness and decreasing human errors. Thus, the results of this study have implications for both academia and industry. Involving students in research projects that provide them with hands-on access to industry representatives better prepares them to be active, contributing members of the aviation industry upon graduation. The gap between book knowledge and knowledge gained through direct experience within industry is lessened through such applied research strategies. Moreover, the interdisciplinary nature of this research project serves as a simulation of the type of situations students are likely to experience should industry heed the results of this research and train employees to work directly with relevant colleagues from other departments or career fields (e.g., pilots and maintenance technicians in the resolution of airplane maintenance discrepancies). Being part of realistic simulations like this allows students to make mistakes in a safe learning environment yet promotes transferring these experiences to the actual aviation environment where the ramifications of similar errors could be much more harmful.

For industry, the interdisciplinary student research teams point to an effective way to integrate career fields through an applied training project. For example, by working together on reducing the potential for latent and active human errors, pilots and maintenance technicians may better realize and understand the importance of integrated systems thinking and interaction in the reporting of maintenance discrepancies.

LIMITATIONS

Although this study provides some important implications for improving existing training and safety systems, it is not without limitations. Two main limitations were evident. First, the approach to developing the questions and distributing the surveys may have influenced potential and actual respondents. For example, the wording of the questions may have skewed responses in a particular direction or discouraged recipients from filling out the survey. Future research is needed to test the reliability and validity of a larger pool of survey questions regarding the maintenance discrepancy reporting process and the involvement of interdisciplinary work team members. This may improve both the sample size and the generalizability of the responses. Second, more consistent follow-up measures could have increased the response rate.

CONCLUSION

Despite the limitations of this research project, the necessary evolution of human factors theory, research, and practice were manifest in this study. At the grassroots level, professional pilots, maintenance technicians, and aviation students are recognizing the need for training that transcends traditional departmental boundaries in favor of integrating individuals across the organizational system. This approach to CRM represents a paradigm shift in ways of thinking about and designing training. Training developed within this perspective would emphasize ongoing, interdepartmental, face-to-face, experiential interaction to insure that skills learned readily translate to the daily work environment. Further, the findings of this study promote interdisciplinary training as a way to decrease both latent and active safety errors in the maintenance discrepancy reporting process. The primary aviation industry goals of safety and on-time flights are team goals not individual or department-specific goals. Clearly, training that addresses these objectives needs to be sufficiently integrated across departments and career fields to be maximally effective.

REFERENCES

Bradley, P. (1995, September). Maintenance resource management. *Business & Commercial Aviation*, 106–112.

Drury, C., Wenner, C. L., & Murthy, M. (1997). *A proactive error reduction system*. Paper presented at the Human Error in Maintenance Conference, San Diego, CA.

Edwards, M., & Edwards, E. (1990). *The aircraft cabin—managing the human factors*. Brookfield, VT: Gower Publishing.

Ewell, C. D., & Chidester, T. (1996, July/August). American Airlines converts CRM in favor of human factors and safety training, *Flight Deck*, 25–29.

Federal Aviation Administration. (1998). *Crew resource management training* (Advisory Circular 120-51C). Washington, D.C.: Federal Aviation Administration.

Federal Aviation Administration. (2000). *Human Factors in Aviation Maintenance and Inspection: Research & Development*, [Web site]. Available: http://hfskyway.faa.gov.

Graham, D. B., & Kuenzi, J. K. (1997). *Error control systems at Northwest Airlines*. Paper presented at the Human Error in Maintenance Conference, San Diego, CA.

Harle, P. G. (1994). Investigation of human factors: The link to accident prevention. In N. Johnston, N. McDonald, & R. Fuller (Eds.), *Aviation psychology in practice* (pp. 127–148). Brookfield, VT: Ashgate Publishing.

Hawkins, F. H. (1987). *Human factors in flight*. Brookfield, VT: Gower Publishing.

Helmreich, R. L., Merritt, A. C., & Willhelm, J. A. (1999). The evolution of crew resource management training in commercial aviation. *The International Journal of Aviation Psychology, 9*, 19-32.

Maurino, D. F., Reason, J., Johnston, N., & Lee, R. B. (1995). *Beyond aviation human factors: Safety in high technology systems*. Aldershot, England: Ashgate.

National Transportation Safety Board. (1987). *Accident Report: Northwest Airlines Flight 255* (DCA87MA046). Washington, D. C.: National Transportation Safety Board.

Parsons, T. (1951). *The social system*. New York: Free Press.

Proctor, R. W., & Van Zandt, R. (1994). *Human factors in simple and complex systems*. Boston, MA: Allyn and Bacon.

Reason, J. (1996). *Human error*. New York: Cambridge Press.

Weber, M. (1947). *The theory of social and economic organization* (Henderson, A. Parsons, T., Trans.). New York: Free Press.

Westrum, R. (1996). Human factors experts beginning to focus on organizational factors in safety. *ICAO Journal, 6–8*, 26–27.

APPENDIX A
INDUSTRY SURVEY OF PILOTS

Thank you for taking the time to fill out this survey. Please answer the following questions as completely as you can. There are no right or wrong answers. Your answers will be kept strictly confidential.

1. Company you work for:_______________

2. Number of years with the company:_______________

3. How satisfied are you with your job?

1	2	3	4	5	6
very unsatisfied					very satisfied

3a. Number of years as a pilot:______________.

4. Total flight time:__________

5 Do you have any military experience? [] Yes [] No Years:______ Rank:_______

6 What type (s) of aircraft do you fly:______________

7. Licenses or certificates you currently hold (check all that apply):
[] Airframe [] Powerplant [] FCC
[] Private [] Commercial [] Airline Transport Pilot [] other: _________

8 Type ratings:__________________________________

9. Highest level of education completed:
[] High School [] Trade School [] Some College [] College [] Graduate Degree
[] other:______________

10. Age: [] under 25 [] 26-35 [] 36-45 [] 46-55 [] 56+

11. Gender: [] Male [] Female

12. Annual Salary:
[] $25,000 or less [] $26,000-50,000 [] $51,000-75,000
[] $76,000-100,000 [] more than $100,000

13. What is your company's policy for communicating maintenance discrepancies? (check all that apply)
[] written logbook entry [] electronic logbook entry [] phone [] don't have a policy
[] face-to-face reporting [] other verbal reporting [] radio [] don't know
[] other: ____

14. Please indicate how consistently the above policy is followed.

1	2	3	4	5	6
never					always

15. How would you rate the effectiveness of your company's current method of reporting maintenance discrepancies?

6	5	4	3	2	1
very effective					very ineffective

16. Which parts of your company's policy for reporting maintenance discrepancies **WORK WELL**?
____
____

17. Which parts of your company's policy for reporting maintenance discrepancies **DO NOT** work well?
____
____

18. In your opinion, how effectively do mechanics and pilots communicate with each other?

1	2	3	4	5	6
very ineffectively					very effectively

19. How frequently do the following interfere with communication between pilots and mechanics?

	never					always
Acronyms	1	2	3	4	5	6
Technical language	1	2	3	4	5	6
Accessibility to one another	1	2	3	4	5	6
Time constraints	1	2	3	4	5	6
Legibility	1	2	3	4	5	6
Error in write-up	1	2	3	4	5	6
Detail of write-up	1	2	3	4	5	6
Electronic information transfer (for example: ACARS)	1	2	3	4	5	6

20. How often do pilots and mechanics communicate using the following forms of communication:

	very often					very seldom
Written	6	5	4	3	2	1
Face-to-face	6	5	4	3	2	1
Electronic information transfer (for example: ACARS)	6	5	4	3	2	1
Phone	6	5	4	3	2	1
Radio	6	5	4	3	2	1
Other:____________________	6	5	4	3	2	1

21. With regard to the reporting of maintenance discrepancies, how effective are the following forms of communication:

	very ineffective					very effective
Written	1	2	3	4	5	6
Face-to-face	1	2	3	4	5	6
Electronic information transfer (for example: ACARS)	1	2	3	4	5	6
Phone	1	2	3	4	5	6
Radio	1	2	3	4	5	6
Other:______________	1	2	3	4	5	6

22. How helpful are maintenance write-ups in the following areas:

	not helpful					very helpful
Hydraulics	1	2	3	4	5	6
Pneumatics	1	2	3	4	5	6
Electrical	1	2	3	4	5	6
Avionics	1	2	3	4	5	6
Powerplants	1	2	3	4	5	6
Airframe	1	2	3	4	5	6
Flight controls	1	2	3	4	5	6
Other:______________	1	2	3	4	5	6

23. It is easier to communicate with a pilot who is:
[] Male [] Female [] No preference

24. In general, I get better write-ups from:
[] Males [] Females [] No preference

25. Generally, it is easier to communicate with a mechanic who is:
[] Older than I am [] Younger than I am [] The same age as I am [] No preference

26. Do you agree that communication barriers are created by age differences?

1	2	3	4	5	6
strongly disagree					strongly agree

27. As a pilot, do you feel you are **MENTALLY**:

1	2	3	4	5	6	7
inferior to pilots			equal to pilots			superior to pilots

28. As a pilot, do you feel you are **TECHNICALLY**:

7	6	5	4	3	2	1
superior to pilots			equal to pilots			inferior to pilots

29. As a pilot, do you feel you are **VIEWED** by mechanics as **MENTALLY**:

1	2	3	4	5	6	7
inferior to pilots			equal to pilots			superior to pilots

30. As a pilot, do you feel you are **VIEWED** by mechanics as **TECHNICALLY**:

1	2	3	4	5	6	7
inferior to pilots			equal to pilots			superior to pilots

31. After a flight, how **WILLING** are **MECHANICS** to talk about maintenance problems?

6	5	4	3	2	1
very willing					very unwilling

32. After a flight, how **WILLING** are **PILOTS** to talk about maintenance problems?

1	2	3	4	5	6
very unwilling					very willing

33. After a flight, how **AVAILABLE** are **PILOTS** to talk about maintenance problems?

1	2	3	4	5	6
not available					very available

34. After a flight, how **AVAILABLE** are **MECHANICS** to talk about maintenance problems?

6	5	4	3	2	1
very available					not available

35. How would you rate your understanding of the entire maintenance reporting system?

1	2	3	4	5	6
do not fully understand					fully understand

36. Do you think that the training/instruction about the entire maintenance reporting system has been:

1	2	3	4	5	6
very inadequate					very inadequate

37. To what extent do you think a mechanic knows YOUR job?

6	5	4	3	2	1
very knowledgeable					not very knowledgeable

38. I think of mechanics as colleagues. [] Yes [] No

39. A class including both pilots and mechanics, based on communication and/or crew resource management, would be beneficial to the work environment: [] Yes [] No
Why or why not?____
____

40. Current methods of maintenance discrepancy reporting need improvement.

1	2	3	4	5	6
strongly disagree					strongly agree

41. What percentage of the time do you think miscommunication between pilots and mechanics is a problem in maintenance write-ups? (circle one)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

42. Maintenance write-ups are **NOT** important.

1	2	3	4	5	6
strongly disagree					strongly agree

43. Regarding maintenance discrepancy reporting, the application of a standardized debriefing or interview process, to supplement the written data, would help minimize miscommunication.

1	2	3	4	5	6
strongly disagree					strongly agree

Thank you for your cooperation in filling out this survey—you have made an important contribution to aviation research!

APPENDIX B
INDUSTRY SURVEY OF AVIATION MAINTENANCE TECHNICIANS

Thank you for taking the time to fill out this survey. Please answer the following questions as completely as you can. There are no right or wrong answers. Your answers will be kept strictly confidential.

1. Company you work for:_______________
2. Number of years with the company:_______________
3. How satisfied are you with your job?

1	2	3	4	5	6
very unsatisfied					very satisfied

3a. Number of years as a mechanic:______________.

4. Do you have any military experience? [] Yes [] No Years:_______ Rank:______
5. What type (s) of aircraft do you work on:______________
6. Licenses or certificates you currently hold (check all that apply):
   [] Airframe [] Powerplant [] FCC
   [] Private [] Commercial [] Airline Transport Pilot [] other: ______
7. Type ratings:__________________________________
8. Total flight time:____________
9. Highest level of education completed:
   [] High School [] Trade School [] Some College [] College [] Graduate Degree
   [] other:______________
10. Age: [] under 25 [] 26-35 [] 36-45 [] 46-55 [] 56+
11. Gender: [] Male [] Female
12. Annual Salary:
    [] $25,000 or less [] $26,000-50,000 [] $51,000-75,000
    [] $76,000-100,000 [] more than $100,000
13. What is your company's policy for communicating maintenance discrepancies? (check all that apply)
    [] written logbook entry [] electronic logbook entry [] phone [] don't have a policy
    [] face-to-face reporting [] other verbal reporting [] radio [] don't know
    [] other: ____
14. Please indicate how consistently the above policy is followed.

1	2	3	4	5	6
never					always

15. How would you rate the effectiveness of your company's current method of reporting maintenance discrepancies?

6	5	4	3	2	1
very effective					very ineffective

16. Which parts of your company's policy for reporting maintenance discrepancies **WORK WELL**?

____
____

17. Which parts of your company's policy for reporting maintenance discrepancies **DO NOT** work well?

____
____

18. In your opinion, how effectively do mechanics and pilots communicate with each other?

1	2	3	4	5	6
very ineffectively					very effectively

19. How frequently do the following interfere with communication between mechanics and pilots?

	never					always
Acronyms	1	2	3	4	5	6
Technical language	1	2	3	4	5	6
Accessibility to one another	1	2	3	4	5	6
Time constraints	1	2	3	4	5	6
Legibility	1	2	3	4	5	6
Error in write-up	1	2	3	4	5	6
Detail of write-up	1	2	3	4	5	6
Electronic information transfer (for example: ACARS)	1	2	3	4	5	6

20. How often do pilots and mechanics communicate using the following forms of communication:

	very often					very seldom
Written	6	5	4	3	2	1
Face-to-face	6	5	4	3	2	1
Electronic information transfer (for example: ACARS)	6	5	4	3	2	1
Phone	6	5	4	3	2	1
Radio	6	5	4	3	2	1
Other:______________	6	5	4	3	2	1

21. With regard to the reporting of maintenance discrepancies, how effective are the following forms of communication:

	very ineffective					very effective
Written	1	2	3	4	5	6
Face-to-face	1	2	3	4	5	6
Electronic information transfer (for example: ACARS)	1	2	3	4	5	6
Phone	1	2	3	4	5	6
Radio	1	2	3	4	5	6
Other:______________	1	2	3	4	5	6

22. How helpful are maintenance write-ups in the following areas:

	not helpful					very helpful
Hydraulics	1	2	3	4	5	6
Pneumatics	1	2	3	4	5	6
Electrical	1	2	3	4	5	6
Avionics	1	2	3	4	5	6
Powerplants	1	2	3	4	5	6
Airframe	1	2	3	4	5	6
Flight controls	1	2	3	4	5	6
Other:______________	1	2	3	4	5	6

23. It is easier to communicate with a pilot who is:
[] Male [] Female [] No preference

24. In general, I get better write-ups from:
[] Males [] Females [] No preference

25. Generally, it is easier to communicate with a pilot who is:
[] Older than I am [] Younger than I am [] The same age as I am [] No preference

26. Do you agree that communication barriers are created by age differences?

1	2	3	4	5	6
strongly disagree					strongly agree

27. As a mechanic, do you feel you are **MENTALLY**:

1	2	3	4	5	6	7
inferior to pilots			equal to pilots			superior to pilots

28. As a mechanic, do you feel you are **TECHNICALLY**:

7	6	5	4	3	2	1
superior to pilots			equal to pilots			inferior to pilots

29. As a mechanic, do you feel you are **VIEWED** by pilots as **MENTALLY**:

1	2	3	4	5	6	7
inferior to pilots			equal to pilots			superior to pilots

30. As a mechanic, do you feel you are **VIEWED** by pilots as **TECHNICALLY**:

1	2	3	4	5	6	7
inferior to pilots			equal to pilots			superior to pilots

31. After a flight, how **WILLING** are **PILOTS** to talk about maintenance problems?

6	5	4	3	2	1
very willing					very unwilling

32. After a flight, how **WILLING** are **MECHANICS** to talk about maintenance problems?

1	2	3	4	5	6
very unwilling					very willing

33. After a flight, how **AVAILABLE** are **PILOTS** to talk about maintenance problems?

1	2	3	4	5	6
not available					very available

34. After a flight, how **AVAILABLE** are **MECHANICS** to talk about maintenance problems?

6	5	4	3	2	1
very available					not available

35. How would you rate your understanding of the entire maintenance reporting system?

1	2	3	4	5	6
do not fully understand					fully understand

36. Do you think that the training/instruction about the entire maintenance reporting system has been:

1	2	3	4	5	6
very inadequate					very inadequate

37. To what extent do you think a pilot knows YOUR job?

6	5	4	3	2	1
very knowledgeable					not very knowledgeable

38. I think of pilots as colleagues. [] Yes [] No

39. A class including both pilots and mechanics, based on communication and/or crew resource management, would be beneficial to the work environment: [] Yes [] No
Why or why not?____
____

40. Current methods of maintenance discrepancy reporting need improvement.

1	2	3	4	5	6
strongly disagree					strongly agree

41. What percentage of the time do you think miscommunication between pilots and mechanics is a problem in maintenance write-ups? (circle one)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

42. Maintenance write-ups are **NOT** important.

1	2	3	4	5	6
strongly disagree					strongly agree

43. Regarding maintenance discrepancy reporting, the application of a standardized debriefing or interview process, to supplement the written data, would help minimize miscommunication.

1	2	3	4	5	6
strongly disagree					strongly agree

Thank you for your cooperation in filling out this survey—you have made an important contribution to aviation research!

APPENDIX C
INTERDISCIPLINARY STUDENT RESEARCH TEAM SURVEY

Post-Test Perceptions Survey

THANK YOU for taking a few minutes to reply to this follow-up survey. There are no right or wrong answers; we are interested in your most truthful response to the questions and issues. Your answers will be kept strictly confidential.

1. Age __________ 2. Gender ______ male _____ female

3. What year in school are you? _____Freshman _____ Sophomore
_____ Junior _____ Senior

4. Circle the number that corresponds with your current level of satisfaction with your major.

Very Dissatisfied 1 2 3 4 5 6 7 **Very Satisfied**

5. Since beginning work on this research project, what has happened to your level of satisfaction with your major? (check one)
_____ Gone Up _____ Stayed the Same _____ Gone Down

If your satisfaction with your major has changed, what occurred to influence the change?

6. Describe your background or experience in aviation maintenance (i.e., courses taken, internships, work experience).

Do you have an A & P certificate? __________

7. Describe your background or experience in aviation flight operations (i.e., courses taken, internships, work experience).

Ratings and Certificates? ____

Total Flight Hours? ____

8. Describe your background or experience in aviation management (i.e., courses taken, internships, work experience).

9. Describe your background or experience in communication such as; public relations, customer service (i.e., courses taken, internships, work experience).

10. Describe any training you have received on how to write-up airplane maintenance discrepancies.

11. Have you ever written or read an airplane maintenance discrepancy report? _______
If yes,
What was your general impression of the report(s)?

12. Did you also speak to the maintenance technician or pilot about the discrepancy?
If yes,
What was your general impression of this interaction?

On the scales below, please indicate your feelings about the various jobs associated with aviation. Circle the number that best represents your feelings. Numbers “1" and ”7" indicate a strong feeling. Numbers “3" and ”5" indicate a weak feeling. Number “4" indicates you are undecided or don’t know. Please work quickly. Remember, there are no right or wrong answers.

	Aviation Mechanics	1	2	3	4	5	6	7	
	Pilots	1	2	3	4	5	6	7	
13.	**Doesn’t think like me**								**Thinks like me**
	Communication Spec.	1	2	3	4	5	6	7	
	Aviation Management	1	2	3	4	5	6	7	

	Aviation Mechanics	1	2	3	4	5	6	7	
	Pilots	1	2	3	4	5	6	7	
14.	**From social class similar to mine**								**From social class different from mine**
	Communication Spec.	1	2	3	4	5	6	7	
	Aviation Management	1	2	3	4	5	6	7	

	Aviation Mechanics	1	2	3	4	5	6	7	
	Pilots	1	2	3	4	5	6	7	
15.	**Behaves like me**								**Doesn’t behave like me**
	Communication Spec.	1	2	3	4	5	6	7	
	Aviation Management	1	2	3	4	5	6	7	

	Aviation Mechanics	1	2	3	4	5	6	7	
	Pilots	1	2	3	4	5	6	7	**Economic situation is like mine**
16.	**Economic situation is different from mine**								
	Communication Spec.	1	2	3	4	5	6	7	
	Aviation Management	1	2	3	4	5	6	7	
	Aviation Mechanics	1	2	3	4	5	6	7	
	Pilots	1	2	3	4	5	6	7	
17.	**Similar to me**								**Different from me**
	Communication Spec.	1	2	3	4	5	6	7	
	Aviation Management	1	2	3	4	5	6	7	
	Aviation Mechanics	1	2	3	4	5	6	7	
	Pilots	1	2	3	4	5	6	7	
18.	**Status like mine**								**Status different from mine**
	Communication Spec.	1	2	3	4	5	6	7	
	Aviation Management	1	2	3	4	5	6	7	
	Aviation Mechanics	1	2	3	4	5	6	7	
	Pilots	1	2	3	4	5	6	7	
19.	**Unlike me**								**Like me**
	Communication Spec.	1	2	3	4	5	6	7	
	Aviation Management	1	2	3	4	5	6	7	
	Aviation Mechanics	1	2	3	4	5	6	7	
	Pilots	1	2	3	4	5	6	7	
20.	**Background different from mine**								**Background similar to mine**
	Communication Spec.	1	2	3	4	5	6	7	
	Aviation Management	1	2	3	4	5	6	7	

Based on your general knowledge and the information you have gained by working on this project, answer the following questions in your own words.

21. List the *responsibilities* of:

an *aviation maintenance technician*.

a *communication specialist*.

a *pilot*.

aviation management.

22. What is involved in the *typical day* of:

    a *communication specialist*?

    aviation management?

    a *pilot*?

    an *aviation maintenance technician*?

23. What do you think is *most important* to:

    an *aviation maintenance technician*?

    a *communication specialist*?

    a *pilot?*

    aviation management?

24. How does aviation management's work *differ* from your work in the aviation environment?

    How does an *aviation maintenance technician's* work differ from your work in the aviation environment?

    How does a *communication specialist's* work *differ* from your work in the aviation environment?

25. What *kind of training* do you think *aviation management* receives?

    What *kind of training* do you think *aviation maintenance technicians* receive?

    What kind of *training* do you think *communication specialists* receive?

26. Are you aware of any *nicknames/terms/phrases* that are used in reference to each of the following groups? If so, please write the nickname/term/phrase and explain what it means.

    aviation maintenance technicians

    What does it mean to use this *nickname/term/phrase*?

    pilots

    What does it mean to use this *nickname/term/phrase*?

    aviation management

    What does it mean to use this *nickname/term/phrase*?

    communication specialist

    What does it mean to use this *nickname/term/phrase*?

27. List below the **pros** and **cons** of working on this aviation research project.

    Pros **Cons**

28. Circle the number that corresponds with your overall level of satisfaction with this research project.

    Very Dissatisfied 1 2 3 4 5 6 7 **Very Satisfied**

Thank you, again, for completing this survey and being involved in this research project!!