# 14.0 PRACTICAL CONSIDERATIONS OF MAINTENANCE HUMAN FACTORS FOR LINE OPERATIONS

*Aviation Maintenance Human Factors Research Team,*
*Purdue University*
*Gary M. Eiff, Ph.D., Denver Lopp, Zoe Abdul, Mike Lapacek, Tim Ropp*

## INTRODUCTION

The diverse nature of operations within today's complex aerospace industry gives rise to dramatically different maintenance structures. While the dynamics of aviation maintenance operations and the associated technician human factors issues which impact safety and efficiency have been the focus of international efforts to reduce accidents and incidents, little recognition has been given to the varying effects imposed by unique maintenance environments. The fact that aviation maintenance assumes many forms and that each environment is dependent on the context imposed by the nature and purpose of the specific maintenance operation results in human factors issues which are situationally dependent. It should be evident to the reader that the assessment of systemic and technician communication issues as viewed from the general aviation maintenance environment are dramatically different from similar issues evaluated from the airline heavy maintenance operation perspective. Within the general aviation environment, technicians deal less often with "shift turn-over" and "referred" maintenance communications. Likewise, situational awareness becomes dramatically different when viewed within the context of "hangar maintenance" as opposed to similar issues imposed by the "line maintenance" perspective.

In order to effect pragmatic solutions within any industry setting, the study of human error and its relationship to the human dynamics of the technicians who perform maintenance within the context of that structure, the assessment and derived solutions must carry with it the contextual specificity of human factors unique to that environment. To gain insight into the unique applicability of aviation maintenance human factors within a single maintenance environment, a longitudinal study of major airline "line maintenance" operations was initiated at Purdue University. Limiting the study's assessment to one maintenance environment provided valuable insight into many of the dynamics which drive human error during the receipt, line maintenance, and dispatch of large aircarrier aircraft.

## DESCRIPTION OF THE RESEARCH STUDY

The nature of the research study design was one of a "pilot study" designed to identify, define, and classify human factor issues which impacted human error within the "line maintenance" environment. As such, the design did not collect empirical data which was statistically rendered but rather collected anecdotal information and observations which could be used to structure future inquiry. While statistical "significance" of the study could not be evaluated, numerous "apparent" issues important to human errors incurred during line maintenance operations were exposed by the study. The study was a multifaceted design which encompassed observations at numerous line operation locations of four aircarriers over a year and a half period. The research project was conceived and supervised by faculty with extensive aviation industry maintenance experience. While some research observations were performed by faculty researchers to insure the appropriateness and validity of the observation methodology, student researchers were used to make the majority of observations. All student researchers were required to complete a human factors course and receive training in observational research techniques prior to participating in the project. One facet of the research involved pairing student researchers with aircarrier line maintenance technicians and allowing them to "job shadow" the technician for an entire shift. After completing the shift, researchers recorded their observations on prepared "observation forms" to insure representativeness of the data. Another facet of the research involved having student researchers "shadow" maintenance managers at different levels of the operation including the Vice President level. This allowed the researchers to assess the impact of management decisions and policies on individual technician human factors issues. The use of student researchers as observers resulted in an unexpected level of openness and sharing of feelings by technicians. It is assumed that this resulted from the fact that technicians perceived the students as less "threatening" than internal evaluation teams or consultants.

### Error Classification Taxonomy

It was felt by the research faculty that a central construct for the evaluation of the observational data was necessary in order to effectively structure the classification and analysis of the various impacts of human factors issues on error generation and propagation within the line maintenance environment. The literature defines several taxonomies for classifying and analyzing human errors.[1] Generally, human errors may be classified by their origin, type, level, or the purpose to which the resulting error analysis will be used. The central construct used for classifying, categorizing, and analyzing the observational data of this research project involved a hierarchical structure of error origin and type. Error origin was chosen as the primary classification criteria since it leads directly to the development and application of practical solution methods.

The origins of human errors are generally differentiated by whether the error was caused by the individual involved in the incident or by faulty design of equipment or procedures used by the individual which compelled them to make the mistake. This classification scheme focuses on determining whether the source of the human error was "inside" the technician (endogenous) or originated from "outside" the technician (exogenous).[1] Endogenous errors are attributable to such factors as individual choice of aberrant behavior, poor judgment or decisions, and lack of adequate training. Exogenous errors are errors generated by circumstances such as incorrect or inadequate policies or procedures, poor equipment designs, and tooling or working condition limitations or stressors. Determining the origin of the error not only provides for a sound method of classification, it also provides insight into appropriate methods for addressing the remediation of those errors. Exogenous errors require corrective action such as changes in policies or procedures, redesign or repair of equipment, changes in workstation or work place design or layout, and the control or reduction of the effects of work related stressors. Endogenous errors indicate a need for training or motivation of technicians.

Once categorized as to the error's origin, the data was further classified as to the type of error committed so that an understanding of the error mechanism might be achieved. Error types represent "categories of error distinguished by differences between actual and desired behavior."[1] This classification scheme differentiates between such types of causes of undesirable outcomes as errors of commission, omission, intrusion, substitution, repetition, and sequencing. Subdivided in this way, observed behaviors provide valuable insight into the source, nature, and causality of human error events. This, in turn, allows some measure of understanding which may be used to formulate intervention strategies and may eventually lead to the potential predictability and/or possible prevention of such errors.

## STUDY RESULTS

Observational data from the various facets of the study were combined and viewed collectively in order to evaluate each of the observed human factors issues from several relevant perspectives. The numerous human factors identified in the study were then grouped into categories of seemingly similar influence. Once similar influences were formulated and the categories delineated, the human factors issues were evaluated as to their observed impact of "Dirty Dozen" items. This was done because of the salient nature of the "Dirty Dozen" items to industry wide error reduction strategies and safety efforts. Although all of the observed issues could not be presented in the short format of this paper, the following groups of issues were among the most prominent factors identified during the study.

### Unchangeable Constants

Among the most prominent and frequent of human factors which influenced error generation within line maintenance operations were environmental factors which are beyond pragmatic control. Issues such as weather conditions, lighting, high levels of auditory noise, intense visual noise and work related stressors as well as shift induced issues such as circadian rhythm were not addressed in this paper despite their importance. This was due to the fact that these issues were considered to be readily apparent, characterized as "no brainers" by one industry official, and widely addressed. Rather, the focus of the paper centered on observed issues which are less recognized as contributing to error and the erosion of safety within line maintenance operations.

### Facility Design

An evaluation of the collective observations suggested that the physical design of the facility where line technicians worked had the greatest diversity of influence on the potential for error generation within the line maintenance environment. Observations determined that facility design directly influenced ten of the twelve "Dirty Dozen" items used throughout industry for evaluating the potential erosion of safety and the propensity for error generation.

In most cases, facility design seemed to be an afterthought with regards to its influences on the technician and the daily operations of line maintenance. Observations at numerous line maintenance stations across the United States found that the overlooked concept of facility design, more specifically the functional design and use of line maintenance zones and ready rooms, had a notable impact upon human factor characteristics that influenced aircraft related errors. Managers concerned about implementing effective error management techniques within the line maintenance environment would be well advised to evaluate the collective effect facility design has on operational safety and effectiveness. Specifically, considerations in ready room and gate design can have a major impact on human factors issues such as communication, complacency, knowledge, distraction, team building and effectiveness, fatigue, resource availability, assertiveness, awareness, and the development of normative behaviors.

For the purpose of illustration, consider two contrasting facility designs observed during the study and their impact on human factors issues. The diagram in Figure 14.1 shows the general facility layout of one line maintenance operation area observed during the study. An evaluation of the station's historic record of safety, efficiency, and errors demonstrated that its propensity for error generation was much lower than other observed stations. In fact, the airline characterized this station as one of its best stations. The research team attributed much of the station's success to intrinsic design features of the facility's physical layout.

**Figure 14.1 Station A - An effective facility design**

The technical workforce at this station was determined to exhibit characteristics which included a well developed team-centered work culture composed of highly motivated technicians who possessed exceptional situational awareness and fostered good communications. Of particular interest in this design, and probably the most critical facet of the facility's influence on the technicians, was the physical separation of the maintenance technicians from the ramp service personnel. The maintenance technician and ramp personnel ready rooms were physically separated by a common lunch/vending area. The open hallway between the two areas allowed easy access for either technicians or ramp personnel should they need information from or need to coordinate activities with the other workforce. The lunch/vending area represented a common meeting place which allowed members from both groups the opportunity to socialize with each other if they desired. The availability of tables and adequate space in each of the separate ready rooms also allowed technicians the opportunity to congregate in a homogeneous technical group if that was preferred. Most maintenance professionals preferred to continue their interaction with other technicians within the ready room area producing a communal structure which promoted greater communication, group problem solving, and informal training.

A key effect of the separation with access which the design provided was the retention of the professional identity of each group without a feeling of alienation. While both groups maintained relatively the same work goal, that of on-time dispatch of the aircraft, these goals were approached from very notably different perspectives and with different task and time priorities. In contrast to stations where groups were mixed as a result of the design of the structure, there appeared to be a more composed and concerted focus on the immediate and long-term tasks for the day. Technicians demonstrated a greater perception of their importance to successful operations, exhibited a greater sense of self-worth, and showed a willingness to develop team qualities and shared responsibility and effort, as well as a marked difference in their ability to proactively assess and plan for future operational needs.

Another important facet of the facility's design was the immediate access to an array of various reference materials and computer terminals at the rear of the ready room. This provided immediate and unimpeded access to the information necessary to effect appropriate and timely repairs and servicing. Tool rooms and computer based training terminals were located immediately off of the AMT ready room in an adjacent room. The easy access to tools facilitated more efficient resolution of non-routine repairs. The ready availability of training material resulted in a greater utilization by technicians with the resultant effect of a more highly educated and knowledgeable workforce.

It was interesting to note that the homogeneity of the technical workforce fostered by the facility's design resulted in conversations which tended to be predominately technical in nature. Shared experience, group problem solving, and informal training between technicians were widely evident throughout the ready room environment. The technical nature of interpersonal communications remained prominent even when the conversation was not work related. Such communications ranged from the use of home computers to sharing various training tapes and materials. The lack of distracting interruptions from non-technical individuals also seemed to create an environment which promoted creativity. One maintenance technician proudly provided a demonstration of a checklist computer program he had developed specifically for a common gate check performed at this station. The group's desire to maintain an atmosphere free of non-technical distractions even carried over to their use of the television in their work area. Despite the fact that a television was provided in the maintenance technician common gathering area, it was seldom on or, when it was on, was normally tuned to a news or weather program.

Two structural features in the layout of the ready room appeared to play a key role in the level of perceived team function and job focus. One feature was the location of the head maintenance technician's desk adjacent to the main door which led to the gate areas. The head maintenance technician, charged with supervisory duties and task flow, was separated from the technicians only by a waist high partition as they moved back and forth from their gates. This facilitated greater interaction and communication directly between the technicians and the maintenance supervisor. This face to face interaction not only provided greater oversight of tasks but also generated greater communications regarding problems encountered. It also provided an immediacy regarding the status of the various aircraft at the gates which provided a heightened situational awareness.

The active presence of an established team leader, the maintenance supervisor, created greater team identity and generated a constant flow of communication which seemed to be a factor in maintaining the high degree of job focus and task related conversation among group members. The interactive nature of technical communications between all maintenance technicians in the room insured that technical problems or questions were immediately subject to the scrutiny of the whole group. This often resulted in a cohesive resolution of the issue due to the large knowledge and experience base shared by the technicians, which included the team's leader. Difficulty with flight departures had an immediate communication path to the head maintenance technician. Also an important facet of this face to face interaction was the team leader's ability to assess nonverbal cues which could alert him to difficulties or changes in the attitudes of his workers. Human gestures and body languages could be continuously monitored by the team leader for signs of frustration, exhaustion, anger, etc.

The second important feature noted in the facility's design was the placement of a large plate glass window which allowed a panoramic view of much of the gate area and transiting aircraft. By providing an unobstructed view of the gates and the arriving and departing aircraft, all of the team members were able to assess the status of line maintenance operations on a continual basis. Team situational awareness for each flight interaction appeared to begin much sooner and was maintained at a much higher level than by technicians at facilities with dissimilar designs. This heightened awareness promoted greater team action and operational coverage. In cases where one technician was unavoidably delayed for an arriving flight, an adjacent gate technician or other team member was observed to immediately initiate the arrival duties. Situational awareness at the facility seemed to transcend attribution as an individual trait and, instead, took on the nature of being a team characteristic. Providing a direct view of the gate and maintenance work areas not only allowed prompt detection of some early error chain events, but also caused appropriate interventions to be initiated to insure that they did not lead to an incident or accident. This team identification of error events not only provided greater potential for error detection but also provided the additional benefit of facilitating a greater awareness of the causes of errors by each technician and greater vigilance among all of the team members.

Finally, the facility design of Station A had a dramatic effect on the level of distractions impacting technicians working in that environment. Distraction from environmental "noise", auditory, visual, and informational, was reduced by separating the two work groups. Because of the separation from ramp personnel, non-work related discussion and overall noise levels were notably low. Visual distractions caused by personnel "through-traffic" within the ready room were significantly reduced. The distraction caused by a constant bombardment of unrelated information, such as sports scores, idle chit-chat, joke telling, television shows, etc., was not present within the technical ready room at this station. Instead, a professional atmosphere prevailed which concentrated on the exchange of technical and operational information. The resultant task-focus of the group resulted in a work environment devoid of distractions.

Figure 14.2 shows the diagram of a facility design which, except for minor work area arrangement differences, appears very similar to the ready room of Station A. Although this design contained much of the same equipment and resource materials available at Station A and had a similar compliment of technical and ramp personnel, the overall effectiveness of the station and its propensity for generating error were dramatically different. One of the most notable differences in the facility's design was the use of small one or two-person work stations at the individual gates which were intended to provide maintenance technicians an accessible work station near the aircraft for operational convenience during receipt and dispatch of the aircraft. Upon closer examination, however, it is evident that the configuration of the ready room for this station was considerably different than that of Station A. These subtle differences had a dramatic effect on the level of technical communications, distractions, team orientation, and situational awareness of maintenance technicians working within this environment.

By contrast, the work area illustrated in Figure 14.2 represents the general facility layout of a line station which had a history of low technician effectiveness and frequent error generation. Again, the research team ascertained that the facility design had a dramatic effect on many human factors influencing technicians at the station.

**Figure 14.2 Station B - A less effective facility design**

During the observation, the most readily apparent difference was the use of a common gathering area for both ramp personnel and the maintenance technicians. Despite the fact that this room was large by comparison to that of Station A's, moving around within the room was somewhat difficult due to the placement of the large number of tables and the associated flow of human traffic from the combined workforce. It was observed that technical discussions were all but non-existent among maintenance technicians when they were present in this common ready room. The number of technicians who utilized the ready room was also quite small. It was interesting to note that members of these two professional populations elected to congregate in homogeneous groups and seemed to avoid inter-group interactions. Despite the fact that no facility layout feature segregated the two groups, the combined employees at the station naturally polarized into groups of similar profession. This resulted in a division of the ready room with ramp personnel on one side and what few technicians were present on the other.

Station B's facility design also resulted in a greater level of environmental noise which served as distractions to the technicians. Commercial television shows on the ready room's TV were a focal point for the majority of ramp personnel in the common room. By contrast to the television in Station A, this television's volume was kept quite loud and the programs watched were not informational, news or weather, but rather sports and entertaining programs. The elevated volume of the television had the additional effect of forcing interpersonal conversations to become loud and animated. The distraction posed by the ready room environmental noise had the observable effect of forcing technical discussions among maintenance professionals to be very abbreviated. In almost every case, technicians who wished to discuss technical problems or issues were seen retreating to bathrooms, tool rooms, or the ramp area to have those discussions.

Reference materials, manuals, and operations computer terminals utilized by both populations were arranged on a work bench in a common area located in the back of the ready room behind a long partition. Both the ramp service supervisors and the head maintenance technician shared a divided console in this same area. The resultant heavy traffic generated by both ramp and technical workers interfacing with their supervisors produced associated confusion and high levels of auditory noise. These factors deterred technicians from using technical manuals and operational status computers and represented a barrier to timely and adequate interaction with the maintenance supervisor. Interaction between individual technicians and their maintenance supervisor as well as among technicians were characterized as "laborious" and "impossible" in this environment. Several observations involving numerous shifts indicated that maintenance technicians rarely utilized the reference area. This fact had a direct impact on the utilization of necessary technical information for non-routine repair, a factor which directly influenced error generation. It was noted that technicians avoided this area even during break periods and meals. Instead, technicians preferred to remain on the ramp area often "living" in the temporary work areas adjacent to the gates or forced to convert tool rooms into "makeshift" ready rooms. The net effect was to cause technicians to become "loners" and destroy any tendency to become involved in team building activities. A by-product of this tendency was the implementation of radio communication between individual technicians and the maintenance supervisor by one airline. When technicians were asked by the carrier what things were the most distracting influences in their environment, many technicians listed their radio as the most distracting force with which they had to contend.

As mentioned previously, in an effort to find refuge from the confusion and noise of the ready room, technicians disbursed to various locations throughout the ramp area. Technicians not seeking the camaraderie of fellow maintenance professionals most often reverted to isolating themselves in the temporary work stations at the gates. This totally destroyed any tendency of the technical workforce to build teams and dramatically reduced the cooperative problem solving and work support efforts. It also eliminated the ability for technicians to "check" or "follow-up" on each other's work. This had a dramatic effect on the potential for error generation and the reduction of "safety net" solutions to potential problems.

Technicians who stridently pursued interactions with other maintenance professionals often had to resort to extreme and imaginative solutions for establishing a communal gathering place. At stations where there were no exclusive gathering areas for the maintenance technicians, they literally "carved out" makeshift meeting areas for their technical groups. Common areas often converting into makeshift maintenance technician gathering areas included parts delivery stations, ramp vehicle garages, closets, parts or tool rooms, and various storage rooms. In the design shown for Station B, technicians converted a tool room adjacent to the ready room into a technical meeting area. This effectively established a quiet environment with less distractions where technicians could converse about technical issues and collectively generate solutions to technical problems. The room also served the purpose of defining a professional boundary which discouraged non-technicians from interfering with the group focus. It was observed that even though the door to the room was always open, no ramp personnel entered with any regularity.

While these makeshift gathering areas allowed technicians to reestablish team identity and focus, they extracted a severe penalty in several other ways. Most notable was the dramatic reduction in their ability to maintain situational awareness with the status of line operations at the station. This was due in large part to the fact that the room had no windows and technicians had no view of the gate area. Isolation from the ready room and their supervisor also resulted in a dramatic reduction in operational information. It even removed the visual cues generated by changes in the tempo of activity among others which could alert them to situational changes and conditions requiring their intervention. Removal of the technician from the ready room to the makeshift gathering area or to the temporary work station at the gate had the additional effect of making it extremely difficult for the maintenance supervisor to monitor activity, provide guidance, and coordinate work assignments. These factors had the net effect of increasing the probability of error generation at the station.

Since the makeshift gathering area was very small, most of the technicians at the station were forced to remain at their gates, isolated from the other technicians. Possibly as a result of this relative isolation, many maintenance technicians developed detectable levels of conflict between themselves and other gates, other shifts, and ramp service personnel. While technicians readily assisted other technicians when asked during especially troublesome problems or conditions, teamwork and problem solving would cease as soon as the problem was resolved. Absent was the spontaneous offering of assistance noted at Station A.

## Work Station Design

Closely aligned with the issues related to facility design was the location and design of workstations within the line maintenance environment. Inadequate or improper workstation design can not only lead to injury of the worker but has also been proven to contribute to human errors.[2] Like facility design, little effort or thought seemed to have been expended in providing adequate or appropriate workstations for line maintenance technicians. While researchers recognized that the line mechanic's principle workstation, the aircraft, has severe constraints which limit the extent and kind of intervention which can be exercised in supporting aircraft related workstation ergonomics, the fact remains that researchers found little consideration for many station related work areas. Of the seventeen line stations visited during the course of the study, only one gave evidence of any forethought and design accommodation for the ergonomic needs of the technician. It is interesting to note that this exception appeared to be the result of input by the technicians themselves during the design phase of the station.

At all of the stations observed during the study, there appeared to be inadequacies in the understanding, preparation, and design of technician work areas and support equipment. Work area access, lighting, ventilation, temperature and humidity control, and layout were often neglected. In fact, at over sixty percent of the stations, principle work areas had been established by converting parts delivery stations, storage rooms, vehicle garages, closets, or other areas inadequate for the purpose. In addition, work benches, maintenance fixtures, and other important features of the workstation were often "home made" from scrap or leftover materials found around the area. Needless to say, these designs gave no consideration to technician address of the work platform, reach, height, or other important workstation ergonomic parameters.

Even in areas where design had been a consideration, the ergonomics of the work area were generally inappropriate or incomplete. As an example, in reference material and computer areas, the equipment most often was not configured for ergonomic access by technicians and seldom conformed to ergonomic standards. Old or inadequately configured micro-film and fiche readers, computer monitors, and other important informational tools often represented ergonomic hazards for the technician.

The "makeshift" or "make do" attitude perpetuated by the inadequacies of work area design seemed to spill over into other line maintenance environments. Technicians were often observed using paint cans, milk crates, boxes, and other items as stools for reaching work or installing or removing ground service electrical plugs, even when the appropriate equipment was readily available. When a work platform was needed, a fork-lift would do if it was more readily available. These inappropriate solutions often resulted in inadequate work address, poor vision, extended reach, and other ergonomic factors which could lead to injury or error generation.

## Technician Motivation and Self-Concept

Research has determined that the mental state and motivation of the worker plays an important role in controlling work related human errors.[3] How technicians perceive themselves and the importance of their contribution to the overall operation are important considerations in error propagation, safety, worker effectiveness, and efficiency. Observation of line maintenance technicians resulted in the identification of several important issues which impact their perception of self-worth and have a significant impact on their level of personal motivation. The influence of these issues upon the technician's attitude toward their work and general motivation was quite evident in their general appearance, demeanor, interface with other professional groups, and attention to detail.

### *Lack of Professional Status*

Almost without exception, line maintenance technicians were very troubled by feelings that the aviation maintenance professions are grossly undervalued and unappreciated by everyone. These feelings seemed to be reinforced daily by management, other aviation professionals, and even the general public. From the beginning, it became quite obvious that the lack of respect afforded the maintenance professions deeply disturbed most technicians and significantly affected their feelings of self-worth, their feelings about the importance of their contribution to safety and operational effectiveness, and their personal motivation. It would have been easy to dismiss these observations as simply "disgruntled workers" if it were not for the fact that the issues were continuously discussed and caused obvious pain and concern for technicians. The impact that such feelings had on complacency, communication, assertiveness, work related stress, and the development of norms is obvious.

Many issues which affected the technician's feelings of self-concept and influenced their motivation were generated by the aviation workplace. While technicians generally professed that their contributions to safe and efficient flight operations were just as important as those of the pilot, they seemed to unanimously agree that they were not afforded the respect or considerations which pilots receive. These feelings most often manifested themselves in a technician's attempt to dissuade the student researchers from pursuing a career in aviation maintenance. Instead, they would point to the aircraft's flight deck and say "you want to be up there, in the left seat." Repeatedly throughout the study at numerous locations, technicians would relate that management viewed maintenance as "a necessary evil." They obviously felt that their contributions were neither appreciated nor respected.

Career related factors which also influenced their feelings of self-worth were the absence of any discernible career ladder, a stratified pay scale, limited or no feedback about their performance, and the fact that in many environments they are tied to other vastly dissimilar workforce groups during contract negotiations. Most professions have a clearly defined career ladder against which a professional might evaluate their career progress. Milestones along a career ladder are often marked by significant pay incrementation, new certification, the development of new knowledge and skills, or other notable indicators of professional advancement. Flight crews have a very discernible career ladder marked by changes in flight crew status, pay increases, aircraft type ratings, and recurrent training opportunities. Maintenance professionals, on the other hand, have none of these indicators of success.

A recent salary study of maintenance professionals working for airlines showed that pay increases were received by maintenance technicians during their first five years of employment with the carrier.4 After that time, most technicians could expect to receive little or no increase in pay. In addition to a stratified pay scale, the maintenance professions offer little in the form of a structured knowledge or skill development opportunities. For most technicians, having an A&P license is the terminal certification which can be obtained. There are no formal means for recognizing any further certification or education. It was surprising to the researchers to see the enthusiasm and anticipation generated among technicians by the formation of the International Society of Aviation Maintenance Professionals (ISAMP) and its recognition of recurrent training as a requirement for membership status in the organization. The vast majority of technicians observed in the study indicated that they desired training and educational opportunities. In most cases, they gave the impression that training was viewed as a reward and that they did not have the opportunity to learn as much as they thought they needed to do their jobs effectively.

Most technicians indicated that they did not feel that they received the respect they deserved. They often indicated that "management" did not listen to their suggestions or concerns. Since many of them felt that they had valuable insight into operational problems, they took this as a personal affront. Technicians also felt that in the minds of managers they were tied inexorably to other less skilled workforce groups who did not share the weighty responsibility for flight safety.

### *Perception of Public's View of Maintenance*

Technicians are also troubled by their perception of how the general public views aviation maintenance and maintenance technicians. The study indicated that they generally feel that the public does not understand the importance of aviation maintenance, the extensive skill and knowledge possessed by technicians, or the high degree of reliability of aircraft maintenance and its contribution to airline safety. Technicians perceive that they are held in such low esteem by the public that more than one technician confessed that they did not tell friends or neighbors what they did for a living. At one station, a technician offered a copy of Webster's New Collegiate Dictionary as evidence of why the public had such perceptions. The second definition under "grease monkey" in the dictionary reads "an airplane mechanic." At every station, technicians could be heard bemoaning the image presented by the aircraft mechanic, Lowell, on the popular television situation comedy "Wings."

Their concerns seem to be warranted. A study of public perception currently being conducted at Purdue seems to indicate that the public has little knowledge of the true nature of aviation maintenance and holds aviation maintenance technicians in low esteem. While the survey is only in its initial phase of distribution, early results of the survey indicate that about seventy percent of the respondents think the primary cause of aircraft accidents is maintenance related error. When asked what career field aviation maintenance technicians are most similar to, they most often respond "automobile mechanic."

## Inter-professional and Intra-professional Conflicts

Throughout the study's observations, the researchers were struck by the frequency and intensity of interpersonal conflicts which seemed to pervade the work environment. While many of these conflicts seemed to have their roots in the technician's feelings of self-worth or the level of respect they felt they received, these conflicts represented a formidable barrier to effective teamwork, communication, and work related pressures and stressors. These issues, especially the disruption of effective communication and teamwork, were viewed as major influences on error propagation and operational safety.

### *Flight Crew / Technician Issues*

The effective communication of maintenance discrepancies is critical to effective and efficient resolution of maintenance problems. For this reason, the communication between flight crews and maintenance technicians was a critical focus of the research study. Although all of the airlines professed to have good relations between their flight crews and maintenance professionals and invariably had "standard procedures" which dictated that the maintenance technician would meet and debrief the flight crews with regards to maintenance problems on the aircraft whenever possible, the study observations found that technicians most often avoided contact with flight crews. In fact, it was not uncommon for technicians meeting arriving flights to stand at the bottom of the stairs to the aircraft and wait until the flight crews had left the aircraft. When technicians did meet and debrief the flight crews, the interface was often marked by tension and communication was often kept to a bare minimum.

Conflict often arose over disagreement as to the dispatchability of the aircraft, whose "airplane" it was at a particular moment, or what was an appropriate "fix" for a specific problem. The fact that many of these issues were not "real issues" was evidenced by the fact that several technicians were observed who had a history of conflict free interactions with flight crews. These technicians made it a point to establish good lines of communication with the flight crew immediately upon arrival and maintained contact with them throughout the ground operation. These technicians were observed to have fewer "could not duplicate" and "no fault found" results when evaluating maintenance discrepancies and had a lower rate of "deferred" items and dispatch delays.

### *Management / Technician Issues*

Throughout the observations, it was apparent that many technicians harbored a mistrust of management which fostered conflict. Most technicians felt that management would provide resources to maintenance operations only when absolutely necessary. They felt that maintenance was perceived as a "necessary evil" and that expenditures of resources for maintenance needs and training were a very low priority. Technicians felt that management did not listen to their suggestions and concerns and that they had no impact on management decisions. When training programs or changes in procedures were implemented, technicians often viewed them as the current "flavor of the month" and gave them little opportunity to prove their worth. The prevailing attitude among technicians was that management stifled creativity and original thought. These feelings often manifested themselves as poor communications, complacency, breaches in established procedure, and work related pressure and stress. In no case was management observed to be perceived as a member of the "team."

### *Zone, Shift, and Work Function Issues*

Poor cooperation, communication, and teamwork were not limited to relations between professional groups. Researchers observed a significant level of conflict between groups of technicians. These conflicts often took the form of conflict between "zones" or gates, shifts, or hangar maintenance work groups. Especially prevalent were conflicts between line maintenance groups and technicians working in the hangar. The rift was so great between these technicians that it was often characterized as a "wall" or "canyon." These barriers to effective communication, coordination of work effort, and the assignment of blame for incomplete work or damage to the aircraft often resulted in undetected human errors and an erosion of safety.

## SUMMARY

While this two year study of airline line maintenance operations provided valuable insight into many of the dynamic human factors which impact human error generation, operational efficiency, and safety, it is by no means comprehensive or complete. The research study was intended to be a "pilot" study to identify areas for further study. To this end, the project was very successful and enlightening. The findings presented in this paper are by no means all of the issues identified during the course of the project. Many additional human factors were observed to have a dramatic impact on the potential for human error generation as well as operational efficiency, work culture dynamics, and safety. The findings presented in this paper represented some of the most prominent "atypical" human factors issues observed during the study which influenced a worker's propensity to originate human errors while performing aircraft maintenance tasks.

## REFERENCES

1. Senders, J. W., & Moray, N. P. (1991). *Human Error: Cause, Prediction, and Reduction*. Hillsdale, NJ: Erlbaum.

2. Konz, S. (1995). *Work Design: Industrial Ergonomics* (4th Edition). Scottsdale, AZ: Publishing Horizons.

3. O'Brien, T. G., & Charlton, S. G. (1996). *Handbook of Human Factors Testing and Evaluation.* Mahwah, NJ: Erlbaum.

4. FAPA (1992, October). Wages of Technicians at the Airlines. *PAMA News,* 9.

## DR. GARY EIFF

Dr. Gary Eiff (top left) is an Associate Professor in the Aeronautical Technology program at Purdue University. His principle area of instruction is avionics systems and human factors. He has over 30 years of aviation maintenance and avionics experience, primarily in the Corporate/General Aviation community. He is also a Commercial and Instructor rated pilot with over 4,000 flight hours of experience.

## DR. DENVER LOPP

Denver Lopp (top right) is currently an Assistant Professor at Purdue University in the Department of Aviation Technology. His areas of instruction include transport category aircraft maintenance, airline/airport management, and aviation law. Prior to arriving at Purdue, Mr. Lopp had a career ranging from maintenance management to corporate finance at a major air carrier. Outside of the field of aviation, Mr. Lopp owns and operates a multi-state commodities clearing firm.

## MR. MIKE LAPACEK

Mike Lapacek (below left) is currently a graduate student in aviation human factors at Purdue University. He is an instrument rated commercial pilot and is working on his airframe and powerplant license. Mike has been a team leader for human factors research projects throughout the past two years. Mike is expecting to receive his Masters of Science degree in 1998.

## MR. TIMOTHY ROPP

Timothy Ropp (below right) is a graduating senior in Aeronautical Technology. Tim plans to continue his studies and pursue a Masters of Science degree at Purdue upon completion of his maintenance related Bachelors degree. Tim has an A&P license and has been a team member and project leader in various human factors research efforts at Purdue.