10.0 MAINTENANCE HUMAN FACTORS AND ERROR CONTROL

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INTRODUCTION

The goal of reducing human errors in maintenance operations can best be attained through a comprehensive application of human factors principles that goes beyond awareness training in resource management skills. Such an approach must consider the selection and training of personnel, the tools provided to perform the work safely and effectively, and motivational factors. Delta is working toward a full integration of human factors to increase safety in all of our operating divisions. This paper will discuss our efforts to fully integrate sound human factors principles in Technical Operations and in our airport ramp operations.

Corporate Human Factors: A Brief History

Formal human factors integration at Delta Air Lines began in the late 1980's when Crew Resource Management (CRM) training was introduced in our Flight Operations division. The goal of this training was, and continues to be, to provide our pilots with awareness and training in six "non-technical" skill areas: communication, crew coordination, planning, decision making, workload management, and situation awareness management. The introduction of CRM training, in conjunction with a concerted effort toward standardizing flightdeck procedures, was widely credited with increasing the safety and effectiveness of our flight operations system wide.

In 1995, the Corporate Human Factors group was established within the Corporate Safety and Compliance department. The primary mission of this group is to provide services that support the integration of human factors principles throughout the corporation. In addition to working with Flight Operations, Corporate Human Factors provides assistance and support for the development of human factors programs in the Technical Operations (maintenance) and Airport Customer Service (ramp operations) divisions.

The Integration of Human Factors Principles

From the applied perspective of air carrier operations, the primary goal of human factors integration in maintenance (or other operations) is increased safety through a more effective management of human errors that result in injuries and damages. Greater efficiency and improved employee morale are important and desirable by-products of human factors integration; however, safety improvement remains the highest priority.

Typically, the primary means through which human factors principles are formally introduced into an operational domain is through the development and implementation of resource management training programs. As we noted earlier, this is how human factors was introduced into our flight operations; and, as we shall describe, resource management training is an important piece of our approach to human factors integration in maintenance and ramp operations.

Delta Air Lines believes that resource management awareness training is a necessary, but insufficient, piece of a comprehensive approach to Human Factors integration. We recognize that for human factors principles to be fully integrated into our operational environment, it is necessary to look beyond resource management training and to consider other areas of application such as personnel selection, task resources, and motivational systems (Figure 10.1). A high quality training program presented to poorly qualified personnel will yield marginal benefits at best. Similarly, the effective training of improper or poorly designed procedures will not result in improved performance. And, unless the desired behaviors are recognized and reinforced in daily operations, they are likely to extinguish over time.

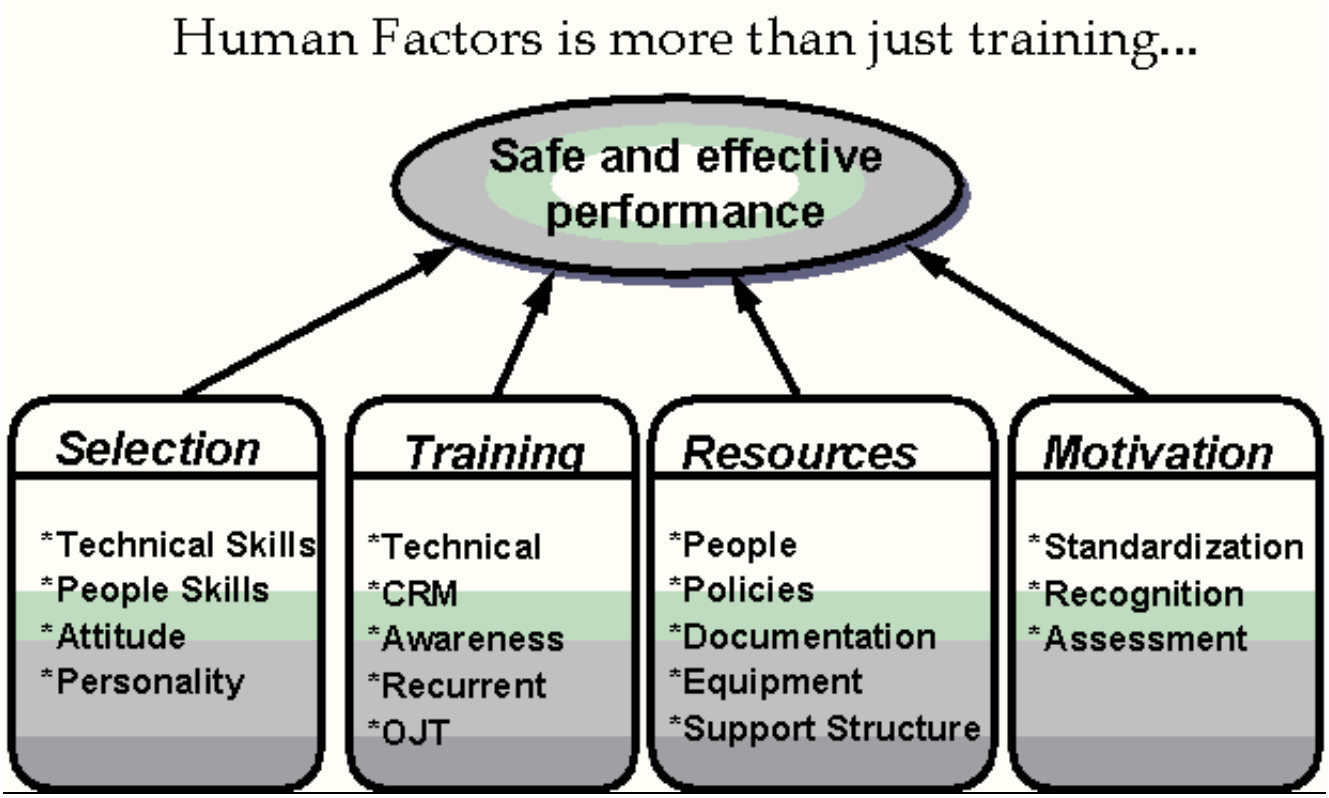

Figure 10.1 A Model for Integrating Human Factors

As we continue to work toward our goal of increased safety through the integration of sound human factors principles, we are taking advantage within each operational domain of opportunities to impact each of the above areas. It has been our experience that while the principles apply across domains, the approach to integration can vary from one domain to the next. In Chapter 9, Dr. Lofaro describes many of the differences between CRM training for pilots and MRM training for mechanics. We have also found that flexibility in the "packaging and delivery" of human factors principles is necessary. The next sections present the initiatives that we have undertaken to date in our maintenance and ramp operations to achieve a full integration of human factors principles.

MAINTENANCE HUMAN FACTORS INITIATIVES

Maintenance Resource Management Training

As a part of our efforts to reduce human error in maintenance, Delta is nearing completion of the development of an initial Maintenance Resource Management (MRM) training course for all Technical Operations employees. This 2-day course will provide awareness and instruction in the key resource management skills of communication, decision making, planning, workload management, situation awareness management, and crew coordination.

Consistent with a primary focus on safety, the MRM course will make extensive use of actual accidents and incidents as case studies for illustration and discussion. Gordon Dupont's "Dirty Dozen Errors In Maintenance" (Chapter 7) will be used to provide a framework for discussing how breakdowns in essential resource management skills can subsequently result in injuries and damage to equipment.

Measures of training effectiveness in terms of desirable shifts in employee attitudes, behaviors, and overall operating performance are recognized as critical to the success of the our MRM training program. A baseline survey of employee attitudes was developed with the assistance of Dr. Jim Taylor of the Institute of Safety and Systems Management at the University of Southern California. The survey was adapted from the Crew Resources Management/Technical Operations Questionnaire (CRM/TOQ) used by Dr. Taylor in previous research dealing with post-training attitude shifts among maintenance personnel.1 The CRM/TOQ is derived from the Cockpit Management Attitudes Questionnaire (CMAQ), which was originally developed to assess flightcrew attitudes and subsequently modified for use with maintenance personnel.2 The CRM/TOQ includes a battery of items designed to tap employee attitudes about leadership responsibility, communication & coordination, recognition and management of stress, and the willingness to voice disagreement. In addition, items measuring respondents' perceptions of safety practices in Technical Operations were included in the survey, as were items that capture attitudes about goal setting and goal attainment.

A similar survey will be administered to employees shortly after they have completed the MRM training course and at regular post-training intervals to assess the immediate and long term impact of training on attitudes. Additionally, we recognize that the goal of MRM training is not simply to change attitudes, but rather to effect behavior change. Therefore, Delta is working with Dr. Taylor and representatives from other airlines to identify and establish behavioral measures and operational performance indicators that can be used to assess training effectiveness.

Lead Mechanic Selection and Training

Perhaps no other group of employees has a greater impact on the daily performance of Technical Operations than our front line supervisors: lead mechanics and foremen. These individuals are responsible for managing resources on the hangar floor or on the flightline to ensure that Technical Operation's safety, reliability and customer service goals are met. Also, the success of behavior-based training programs such as MRM largely depends upon the support of front-line supervisors. To the extent that front line supervisors support and reinforce on a daily basis the behaviors taught in the training program, the program will succeed. If the principles and behavioral skills are not reinforced, the training will be only minimally effective in changing attitudes and behaviors.

It became apparent to management that, although the overall performance of lead mechanics was high, there was unacceptable variability in the performance capabilities of these key personnel within our hangar maintenance operations. Moreover, the areas in which management saw the need for improvement were not technical skills, but rather, non-technical skills such as planning, workload management, and decision making. This prompted a review of the selection criteria and training program for lead mechanics and foremen in our hangar maintenance department.

In the past, lead mechanics in hangar maintenance were nominated and selected through a majority vote of their peers. Obviously, this approach did not always ensure that the best qualified candidate got the job! Currently, candidates for lead mechanic positions are nominated through majority vote by their peers, and the top three candidates are interviewed and the selection is made by a management selection committee. While the current selection process represents an improvement over the past, we have undertaken a program of research to systematically develop selection criteria, and to develop a training curriculum that better meets the needs of our lead mechanics.

As a first step, lead mechanics in our Atlanta hangar maintenance, avionics, hydraulics, and paint departments were given an attitude survey similar to the CRM/TOQ discussed in the previous section (Maintenance Resource Management Training). The survey also included items related to preferred leadership style and several open response questions pertaining to topics such as challenges of the job and perceived training needs. As an independent effort, we have also asked managers in each of the participating departments to evaluate their lead mechanics on a variety of performance dimensions. The survey responses will be correlated with the performance assessments in an attempt to identify desirable attitudinal characteristics.

Currently, we are in the process of encoding and analyzing the survey data. We have completed preliminary content analyses on the responses to the open ended questions, and the pattern of results on those questions appear to support our expectation that the most challenging aspects of being a lead mechanic, and the challenges respondents were least prepared for, are not technical issues. The tabulated responses to the questions, "What is the most challenging part of your job?", "What aspects of your job do you feel you were least prepared for?", and "What are the most important skills you need to be effective in your current position?", reveal that interpersonal and other resource management issues are reported to be the most challenging (Table 10.1).

Table 10.1 Responses to Survey Questions from a Sample of Lead Mechanics

What is the most challenging part of your job?	No. of responses

Human relations/dealing with people	22
Meeting "ready times"	12
Motivating mechanics	7
Coordinating different departments	5
Workload (# of aircraft)	4
Dealing with the corporate 'system'	4
Staying current with technical issues	3
New hire employees	3
Time management	3
Constant changes	3
Doing everyone's job	2
Other (1 each)	4

What aspects of your job do you feel you were least prepared for?	
Human relations/dealing with people	23
Paperwork	12
Computers	11
Lack of training	5
Many skills to know (avionics,eng.,etc.)	4
Policies and procedures	3
Other (1 each)	4

What are the most important skills you need to be effective in your current position?	
People skills	30
Communication skills	27
Technical skills	17
Computer skills	10
Listening skills	6
Organizational skills	5
Decision making skills	5

Management/supervisory skills	5
Leadership skills	4
Coordination skills	3
Motivational skills	2

The responses of the lead mechanics to this set of questions reinforces our awareness that there is an additional set of non-technical skills that lead mechanics must master to become effective leaders. As our data and our anecdotal experiences have shown us, technical proficiency is necessary but not sufficient for effective leadership. As a result, we are conducting further investigations to identify the specific behavioral components in each of the skill areas that contribute to being an effective lead mechanic. Our findings eventually will be fed back into the training curriculum for new lead mechanics, and will enable us to develop a more refined set of tools for identifying and preparing promising candidates for lead mechanic positions early in their careers.

Maintenance Error Reporting Programs

As we stated earlier, the goal of our human factors efforts is to reduce the human errors that result in maintenance-related injuries and damages. It is therefore critical that we develop valid and reliable measures of system performance that relate to that goal and of the behaviors that drive that performance. We are participating in a working group of the Air Transport Association's Subcommittee on Human Factors in Maintenance and Inspection that is focusing on identifying system performance indicators related to human error management.

We are also currently in the process of reviewing the functions and capabilities of our existing incident reporting and tracking system, our Quality Assurance auditing processes, and our Continuous Analysis and Surveillance (CAS) program to determine whether features of these programs can be tailored and consolidated to capture the behavioral antecedents and systemic failures that contribute to incidents and accidents. In addition, we are considering the use of available off-the-shelf incident reporting and tracking systems such as Boeing's Maintenance Error Decision Aid (Chapter 3) and the Aurora Mishap Management System (Chapter 6).

It is also important that we develop mechanisms and a safety culture that promote two-way communication in the identification, reporting, and resolution of issues related to maintenance error in the workplace. This effort will require that we address our internal disciplinary systems, the role of regulatory authorities, and emerging use of the Aviation Safety Reporting System (ASRS) by our maintenance personnel. A grass roots culture must be nurtured within our organization that will support the open reporting of errors and incidents without fear of a "cop on the beat" response from management. We are optimistic that one way in which we can foster a more open reporting culture is through the use of our Continuous Improvement Teams (CIT) program. These teams focus on identifying and implementing process and workplace safety improvements within Technical Operations. We believe that the CIT program can be applied to identifying, reporting, and resolving human factors concerns as well.

RAMP HUMAN FACTORS INITIATIVES

Although the focus of this workshop and these proceedings is the application of human factors principles to maintenance operations, we believe it is worthwhile to briefly discuss some ongoing human factors initiatives in our airport ramp operations. While the general model that drives our human factors efforts on ramp is the same, the operating and training environments for ramp personnel present a different set of constraints and opportunities for integration.

For example, the aircraft handling activity that surrounds the arrival or departure of an airplane is relatively scripted and constrained in time and space. Therefore, the accomplishment of the task is relatively easy to observe and evaluate--in contrast to many maintenance tasks, which require the coordinated activity of several departments over a period of hours, days or weeks. As a result, one of the initiatives described below involves the real time coaching and evaluation of resource management skills on the ramp. Such a program would be difficult to implement in many maintenance operations, but may have potential for application to certain tasks (for example, engine changes). The following sections are therefore provided to illustrate other methods through which human factors might be applied to reducing human error.

Ground Operations Manual (GOM)

In the Spring of 1996, Delta introduced a Ground Operations Manual (GOM) to increase the procedural standardization of airport ramp operations. Prior to the release of the GOM, it was recognized that there was considerable variability in the performance of aircraft handling procedures throughout the system and that this variability contributed to an unacceptable rate of preventable ground damage events. It was common for new employees to learn procedures through verbal coaching on the job. Many station-specific procedures were never written down and were passed along orally from experienced to inexperienced employees. This teaching technique worked effectively as long as Delta maintained an experienced, stable work force. However, when cost-cutting initiatives were introduced in the early 1990's, many of the highly experienced employees accepted early retirement offers and left the company--taking with them this "corporate knowledge." This, in combination with an increased use of contract services, resulted in a disruption to the previously reliable transfer of procedural information. It soon became apparent that a more explicit means of providing procedural guidance was needed; thus, the GOM was developed.

The GOM describes the role expectations--in terms of specific, observable behaviors--for each member of a ground crew engaged in aircraft handling procedures on the ramp. It was recognized early on that behavioral expectations needed to extend beyond technical performance, and should also include expectations for performance in traditional resource management skill areas. As a result, the first chapter in the GOM is entitled, "Human Factors" and provides explicit behavioral expectations in the areas of: communication, crew coordination, workload management, planning, situational awareness, and decision making. For each of these skill areas, a definition of the general concept, a behavioral objective, and specific behavioral expectations for Team Leaders/Lead Agents and all team members are included in the GOM (Table 10.2).

Table 10.2 Example of a Human Factors Skills Section from the Delta Ground Operations Manual (GOM)

Communications
Definition: The exchange of thoughts, messages or information by speech, signals or writing. The activity, both verbal and non-verbal, that is used to transfer information between members of the team. Speak up for anything you see that is unsafe, irregular or not in accordance with procedure. Stop the operation if necessary. Any deviations from briefings or procedures should be communicated immediately. **Some keys to proper communications are:** Team Leader/AIC/ALA • Establish and reinforce communications with all team members • Conduct briefings on operational requirements and expectations • Ensure that all team members understand their roles • Communicate changes in a timely manner All Team Members • Listen actively and ask questions when unsure • Use standard terminology and signals • Give and accept constructive feedback • Know what is expected of you

Classroom Training

With the development of an explicit set of observable behaviors for each of the skill areas in the GOM, we have established a set of behavioral standards that can be trained to. As a next step, we began the development of training programs designed to increase awareness and build skills in each of the six resource management areas. Our goal is to introduce and reinforce resource management concepts and skills throughout the entire training career of our ground operations personnel.

New Hire Training

All new hire employees on the ramp are required to attend a basic ramp operations training course. Resource management skills are being integrated into this course to provide awareness and skills development from the first day on the job.

Ramp Resource Management Training

This course is being developed for all current ramp employees and management, and will provide a general overview of the resource management concepts and skills covered in the GOM. The course will highlight -- using actual accidents and incidents -- how failures in the skill areas can result in injuries, aircraft ground damages, and a negative impact on customer service.

Huddle for Excellence Recurrent Training

All Delta ground crews involved in handling aircraft in the gate area are required to conduct a "Huddle for Excellence" prior to the arrival or departure of each flight. In this "huddle," proper aircraft handling procedures are reviewed, task assignments are made, and the gate area is checked for FOD and ground service equipment. As part of the "Huddle for Excellence" program, all personnel are required to attend annual recurrent training on aircraft ground handling procedures. We are using this annual recurrent training as an opportunity to reinforce ramp resource management skills and to address human factors areas of special concern.

Resource Management OJT

Recently, we successfully completed a trial program at our Atlanta hub which involved the coaching and assessment of resource management behaviors on the job (OJT). A team of selected ground operations personnel were provided resource management skills training and instructed on observation, assessment, and coaching of resource management skills. Using a resource management behavioral assessment form developed for use on the ramp, this team spent a week in each gate area evaluating and coaching the performance of ground crews. At the beginning of the week, the team conducted a pre-training assessment of the ground crews observed. The team then spent four to five days working with and coaching the ground crews on the desired behaviors. At the end of the week, a post-training assessment was conducted and a follow-up assessment was conducted one to two months later.

Preliminary analysis of the behavioral assessments suggests that the OJT coaching resulted in sustained increases in the use of desired resource management behaviors; and, the desired behavioral changes appear to correlate with reductions in ground damage incidents. We are currently working on further developing this program and expanding participation to stations outside of Atlanta.

We are encouraged that this program can potentially provide ongoing reinforcement of resource management skills. Additionally, the performance assessments obtained by the coaching teams can provide a basis for tracking performance improvements and undesirable behavioral trends over time. This information can be used to revise or enhance our training programs and procedures, or to identify additional resource needs related to ramp operations.

SUMMARY

The initiatives that we have undertaken thus far in our maintenance and ramp operations represent the beginning of a comprehensive approach to reducing human error through the integration of human factors principles. This approach recognizes that, to be successful, we must extend beyond resource management training and into areas such as personnel selection, policies and procedures, and recognition/evaluation programs.

It has been our experience that human factors principles apply across operational domains. However, an organization must be flexible in its integration methodology. An initiative that works well on the hangar floor may not work well or apply easily to the ramp or in the component shops.

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