EVALUATING THE EFFECTS OF MAINTENANCE RESOURCE MANAGEMENT (MRM) INTERVENTIONS IN AIRLINE SAFETY

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SUMMARY

This program is designed to help understand and evaluate the impact of Maintenance Resource Management (MRM) training programs, and other MRM interventions, on open communication, error disclosure, and enhanced safety performance. It begins with the measures of attitudes and opinions about communication, cooperation, participation, teamwork, stress management, assertiveness, goal sharing and safety awareness before training is undertaken. The design of this project's evaluation method incorporates a longitudinal, time sensitive data collection approach by comparing the before measures with several follow-up attitude and opinion surveys (immediately after training, and two, six and twelve months following training), as well as the comparing survey data with monthly performance measures.

This report describes one year's evaluation of the effects of four air transport companies' MRM change programs. This evaluation focuses primarily on one of those companies. It is directed to the attitudes and reported behaviors of Aviation Maintenance Technicians (AMTs) and the safety performance of their units. The results reveal a strong positive effect of the initial training, as well as some signs that additional intervention is required in order to sustain the results. Preliminary results from another company, just planning their MRM training are considered in light of the AMTs' results as well other programs studied earlier.

OBJECTIVES

The present paper seeks to describe and validate the effectiveness of five change programs (generically termed Maintenance Resource Management, or "MRM"). The activities evaluated here are in the middle stages of an ongoing MRM training program, or they are in their initial stages of program planning and bench marking. All programs are in U.S. air transportation companies and have been developed for maintenance personnel. The overall goal of these MRM training programs is to establish a long-term commitment to improving safe, dependable and efficient performance through effective communication at all levels in the airline maintenance operations.

To examine the effectiveness of these MRM training programs, Aviation Maintenance Technicians (AMTs) and Technical Operations Managers' attitudes, self-reported behaviors, and performance at the maintenance work unit level are systematically evaluated and measured over time. This study builds on past work[25,28] to examine new aspects of airline maintenance change program evaluation. The present research consists of the following concurrent phases. Only preliminary data for each phase have been obtained during the year of study reported here.

Phase 1 begins the longitudinal tracking of post-training attitudes in several companies through their first full year. Phase 2 is the collection and assessment of safety and other performance indicators of maintenance units. Phase 3 examines longitudinal relationships between the post-training performance results and attitudes of participants.

Phase 1: Longitudinal Tracking of AMT and Technical Operations Manager Attitudes

This project phase undertakes analyses of training participants' attitudes, and self-reported behaviors. This phase uses a set of some 30 validated and reliable questionnaire items (collectively referred to as the MRM/TOQ[26]) developed for obtaining pre-training, post-training, and two, and six month follow-up attitudes and behaviors. Changes over time in the attitudes and maintenance work unit performance are tested using an increased sample size compared with earlier studies.

Phase 2: Longitudinal Tracking of Maintenance Unit Performance

Maintenance unit performance measures (e.g., occupational injury, aircraft and facilities damage, and maintenance paperwork errors) are recorded before the onset of training and after training and examined for significant trend patterns and differences.

Phase 3: Longitudinal Tracking of Correlations Between Attitudes of AMTs and Managers with their Unit's Performance

This project phase focuses on analyses of participants' attitudes, self-reported behaviors, and work unit maintenance performance for relationships among them and with the MRM training. Using data from the basic questionnaire items (MRM/TOQ) characterized in Phase 1, pre-training, post-training, two month, and six month follow-up attitudes and behaviors are correlated with performance.

SUMMARY RESULTS

These results are generally consistent with other reported CRM and MRM training research projects.[7,28,29] Differences in particular results across companies are also reported. Such differences are likely to be the result of phenomena including, but not limited to differences among the design of the MRM programs and among the organizational cultures[11] of the companies themselves.

PRESENT STATE OF THE KNOWLEDGE: MRM PROGRAMS AND EVALUATION

A current theme in aviation maintenance is that good communication and an awareness of the larger environment are required as foundations for changes to safety performance to succeed. It is becoming recognized that this is tantamount to a cultural change -- a series of beliefs: 1) that systems are larger than individuals, but that people collaborating can succeed, 2) that individuals benefit from communication skill training, 3) that top management and union support are essential for a strong culture, and 4) that aviation safety can improve only if it is a central part of the organization's culture.

CURRENT PRACTICES FOR CULTURAL CHANGE IN MAINTENANCE

Practical applications of systems thinking and culture change usually take the form of changes in management behavior, changes in jobs and organization structure, changes in strategy and policy, and/or changes in values. Evidence from aviation maintenance, collected during the 1990's, confirms this.[15,20,23,18,10,2,16] Virtually all of this practice involved communication and collaboration among people.

Continental airlines received wide publicity when they embarked on CRM-type training in maintenance.[4] At the seventh FAA Meeting on Human Factors in Aircraft Maintenance and Inspection John Stelly, an invited speaker, described the first year's positive effects of using the communication training for his airline's more senior Technical Operations personnel. Improvements in ground damage and occupational injury rates were reported as positive outcomes of the training.[18]

At the eighth FAA Meeting on Human Factors in Aircraft Maintenance and Inspection (November, 1993) three invited speakers described the positive effects of new task allocation and communication among maintenance crew members in their three airlines. A change in organization and job design of inspectors at United Airlines was reported, in which inspectors remained accessible during the entire period of heavy checks, stayed in closer communication with mechanics during repairs, and "bought back" their own initial non-routine.[16] These changes were reported to result in lower total check costs, fewer air turnbacks, and higher subsequent quality. A strong and clear organization culture created and sustained by Southwest Airlines' CEO, Herb Kelleher, was reported to result in improved communication between Maintenance and other departments.[2] At TWA, a new program for communication among the International Association of Machinists (IAM), AMTs and maintenance management was said to have resulted in improved quality control.[10]

In another cooperative effort with the IAM, USAirways and the local FAA office (FSDO 19) achieved notable successes in reducing errors in maintenance documentation by developing new channels of open communication among AMTs, maintenance Foremen, and maintenance management.[25,9] This interest in improving performance in maintenance paperwork is not trivial.

As recent accident investigations have shown, maintenance paperwork can have dramatic and life-threatening implications. Incomplete, incorrect, or unclear written communication among maintenance personnel and between them and flight crews have been shown to be contributing factors in at least three fatal North American accidents since 1991.12,13,14

IMPROVING MAINTENANCE RELIABILITY THROUGH OPEN COMMUNICATION

Combination of Planning and Learning

Qantas, the Australian airline, has an unblemished accident record and the company's safety policy emphasizes planning activities to avoid accidents and using an organized approach. But for many safety experts strategic planning is not enough. Management planners always benefit from new information from the field, because complexities of the operational world require that the system be constantly vigilant to new events, new behaviors, new information which can be important safety precursors. A number of programs and techniques have recently appeared to help maintenance systems uncover that new information. Those that encourage the use of mutual trust and open communication among AMTs and their manager have been termed Maintenance Resource Management, or "MRM".5,9

MRM programs are intended to create and develop trustful and open communication. Such open communication is expected to foster the voluntary disclosure of maintenance errors from people at their point of origin, as well as other information vital to strategic planning.

Training Programs to Foster Enhanced Communication and Safety

The Cockpit Resource Management (CRM) training approach was introduced into flight operations during the late 1970s, following several aircraft accidents which clearly involved poor flight crew communication.30 It then spread from civil to military aviation and into air traffic control, and cabin service and cabin maintenance. CRM involved training in several team-related concepts: communication skills, self-knowledge, situation awareness and assertiveness skills.

An adaptation of CRM to maintenance operations was reported as early as 1989,19 but it pursued very limited objectives and achieved only limited success. Shortly thereafter Continental airlines achieved considerable success in its use of a long-term training program which applied a modified version of CRM training for all maintenance management and technical staff support people, as well as a sprinkling of AMTs.

Following a period of limited activity, Continental has resumed its efforts to improve communication with an extended and modified program. It now targets its AMT workforce more specifically than before, and it has re-titled the program "Maintenance Resource Management" (personal communication, J.J.Stelly, Jr.).

The Effect of Continental's MRM Training Program

When Continental's program was suspended in 1994 its results and details were well known to others in the industry. That program succeeded in raising positive attitudes and in boosting maintenance safety results.[18,28,29]

In order to train 2,200 people in three years Continental conducted a session somewhere in the country nearly every week. A stream of visitors came and observed that training and went away with a knowledge of what would succeed and how it worked. Those observers included people with maintenance interest or responsibilities from other airlines (foreign and domestic), from the military, from aircraft manufacturers and other vendors, and from government agencies (including FAA, NASA, and Transport Canada).

MRM Programs Proliferate in the U. S.

Since 1994 a number of maintenance resource management (MRM) training programs have been started in other airlines, repair stations, and training institutes in the United States. Some of these derivative efforts have created course material, curricula, and in some cases provided whole courses to others, allowing them to take part in the MRM process without incurring extensive development costs. One of these recent courses is Transport Canada's well developed and publicized Human Performance in Maintenance Program (HPIM).

Canada Initiates a Resource Management Program for Maintenance Technicians

In the early 1990s Transport Canada began the development of an MRM-type training program. Initiating forces for this action were the outcomes and aftermath of the 1989 accident at Dryden, Ontario.[12] Information about safety initiatives and training for maintenance personnel was collected throughout the industry, and this included the Continental MRM training. The resulting Canadian course, called Human Performance in Maintenance ("HPIM") was designed specifically for technicians. HPIM bears a family resemblance to the Continental MRM program and its course materials, but it is custom-made for its intended audience. HPIM was first made available as a "do-it-yourself" training program in early 1994 and soon became widely known because of its use of relevant and appropriate training materials and its ready availability. Among HPIM's most popular innovations is a set of safety posters, called the "Dirty Dozen," A separate poster was created for each of 12 topics. A list of the "dirty dozen" topics is presented in Table 1.

The HPIM training course was designed to cover, in depth, the first four topics on the left hand list of Table 1. Although all 12 items on the list are addressed during the course of the two day training the remaining eight -- and in particular, the last three in the right hand list -- are mentioned only in passing. The course syllabus of the HPIM includes extensive use of video cases followed by group discussion and active learning modules employing group problem solving exercises. It also includes ample reminders (as well as subsequent, personal follow-up) for participants to be careful in their work and to remember the lessons from the course.

TABLE 1. The "Dirty Dozen" Causes of Maintenance Errors: The First Four Are Emphasized in "HPIM-1"

⇒ Lack of Communication	• Lack of Assertiveness

⇒ Stress	• Lack of Resources
⇒ Fatigue	• Pressure
⇒ Complacency	• Lack of Knowledge
• Distraction	• Lack of Awareness
• Lack of Teamwork	• Norms

The two-day HPIM course is available for use free of charge. The "dirty dozen" posters and related training aids are also available at minimal cost. In its first four years the HPIM has already been presented, sometimes with local modifications, to thousands of participants and observers. Major application of the HPIM course has been its use with over 7,000 participants in airlines in North America, and in sessions conducted by aviation training/ consultant firms. Two Canadian airlines are preparing to make extensive use of the HPIM. A follow-up HPIM-2 training program -- emphasizing "norms" from the dirty dozen, as well as company culture, and written communication -- has recently been developed and is currently available through Transport Canada.3

In recent years airline maintenance departments, large and small, have found encouragement and assistance in undertaking their own MRM programs. Major trends include familiarization programs for maintenance managers designed to emphasize the importance of safety and communication as well as an emphasis on specially created MRM training for AMTs.

Although these trends are well intentioned and, for many purposes, highly successful, obstacles and pitfalls remain for the unwary. Particular problems include training programs implemented as stand-alone programs which are not part of larger, on-going programs to change maintenance culture toward greater teamwork and safety consciousness. Other problems are that such stand-alone training often does not address specific skills training, nor the need to reinforce concepts with an ongoing or recurrent program. An additional problem with the current interest in MRM training is the over-emphasis on training AMTs and allowing a resulting under-emphasis on simultaneously training maintenance managers to achieve the same communication skills and embrace the same safety culture as their workforce.

THE PRESENT STUDY

METHODS

The Setting

During 1996-97, the four airline companies reported here, undertook five MRM programs. A large airline, referred to here as “Co.A”, embarked on two separate programs, one providing MRM training to engineers and the other for its AMTs. Company A MRM training program is planned to continue into 1998. The second and third companies (“Co.B” and “Co.C” respectively) are smaller companies maintaining executive jet aircraft who contracted an external vendor to provide MRM training to all maintenance employees. Those programs have been completed and no plans are known for further activity in either firm. The fourth site reported here, “Co.D,” is a large airline that is beginning to develop its MRM training program as a continuation of programs to improve safety through enhanced communication culture. Company D intends to begin its training in 1998.

The Companies Have Different Training Programs

Company A's AMT MRM program, as well as those of Companies B and C followed the form and curriculum of the Human Performance In Maintenance (HPIM) training package. Essentially the HPIM model calls for two days of classroom training, a number of small-group activities, and an emphasis on the first third of the "dirty dozen" safety obstacles (Table 1).

Companies B and C trained all maintenance personnel, including management, foremen, leads, inspectors, mechanics and others. Because both Company B and C contracted their MRM training to a single outside vendor, these small companies received training that is assumed to be consistent in content and delivery because it is delivered by a single training facilitator

Company A's AMTs training program differs from Companies B and C in several ways. First of all the participants are overwhelmingly AMTs and lead mechanics in line and base maintenance. In fact foremen and managers account for less than one percent (1%) of the respondents to the Co.A AMT pre- and post-training surveys (*cf.*, Appendix B, which contains descriptive statistics for the demographic data from all surveys reported here).

The second difference in MRM training between Co.A AMT program and Companies B and C is decentralization. Company A uses 24 AMT training sites and over 60 facilitators. These facilitators are drawn from the company’s maintenance operations ranks -- and in each session, one is usually a foreman and the other is a rank-and-file union member. Such an arrangement can have powerful consequences. On one hand the facilitators are often known to the participants and are usually respected opinion leaders -- and they are also mainly very talented trainers. On the other hand, among this large force of non-professional trainers, differences in desire and style (not to speak of local site culture) can be reflected in inter-site differences in program content and quality.

A third difference between Company A AMT training and Companies B and C is focus. Company A began their program by training all 1,700 of their line maintenance AMTs first, and only then starting to train all base maintenance hourly personnel. By June 1997 the line maintenance training was largely completed. MRM training for base maintenance personnel in two locations began in earnest during April 1997. By September 1997 (the latest surveys documented in the present report) some 970 non-exempt base maintenance employees had completed the training.

Company A's Engineering MRM program participants are exclusively engineers and engineering assistants or specialists. The Company A Engineering MRM program also differs widely from HPIM, in that it involves only four hours of classroom training, few small group discussion, and replaced the "dirty dozen" situations to avoid, with "cardinal rules" of behavior to follow for safety. The engineers' training stressed speaking out when a problem or error is noticed, even if doing so would be uncomfortable. This focus on assertiveness was illustrated throughout the session with cases and examples, as well as specific points about it in the list of cardinal rules. Company A's engineering and its AMT programs do share similar focus on the effects of stress and work pressure and its management, as well as the importance of teamwork and communication.

Company D has not completed the development of its MRM program, which will share some features of the HPIM, but will also incorporate new sections and material. Company D plans to train all maintenance personnel in the same course by assuring a mix from many departments and hierarchical levels in each session. The company also plans to break their two days of training into a first, initial training day, with the second day six weeks later as recurrent training.

SAMPLES AND UNITS OF ANALYSIS

Individual Respondents as the Focus of Analyses

The five sample programs reported here vary in the composition of their respondents. Three of them (Companies B, C, and D) consist of representative proportions of maintenance management, foremen, leads, support personnel and AMTs. One sample (Co.A Engr.) contains only engineers and engineering assistants. The fifth and largest sample (Co.A AMTs) is composed overwhelmingly of AMTs. To explore some of the effects of the training on all individuals, the data from all training participants, totaled for each MRM program, will be used. The remaining analyses, however, examine the attitudes of respondents who are combined with others in their same work units.

Maintenance Work Units as the Focus of Analyses

The maintenance performance data (classified into categories of "Occupational Safety," "Ground Damage," and "Paperwork Errors") are measured by work units, not by individual respondents. The correlation analyses described in this report illustrate the effect of changes in respondent attitudes associated with the maintenance performance of their work-units. For managers these are the units they lead, and for staff professionals, maintenance foremen, leads and AMTs, these units are the stations and locations to which they belong. In order to accomplish the examination of attitudes correlated with performance, the individual respondent’s attitude data were combined into averages for their appropriate work units.

THE ATTITUDE MEASURE: The "Maintenance Resource Management Technical Operations Questionnaire" (MRM/TOQ)

Prior Experience in Measurement of Attitudes Related to MRM Training

The Maintenance Resource Mgt./Tech Operations Questionnaire" (MRM/TOQ) is a well developed measure for assessing attitudes and opinions of aviation maintenance personnel. The MRM/TOQ is derived from a 1990 version of the Cockpit Management Attitudes Questionnaire (CMAQ) -- a well-known training, evaluation and research tool.[8] The CMAQ questionnaire contained a number of items measuring attitudes that are either conceptually or empirically related to communication and teamwork training provided to flight crews. Taggart[19] revised the CMAQ for use in a maintenance department, and reported positive initial results following CRM training conducted for maintenance managers in late 1989.

Four previous studies have used the Factor Analysis technique to explore and confirm a consistent internal structure for the core CMAQ questionnaire items.[6,22,17,1] In the four studies, using samples of flight crews, maintenance managers, air traffic controllers, and AMTs, respectively, the authors have shown that the relationships among most items in the 18 from the CMAQ clustered into four "factors," or constellations of attitudes. The four factors are shown in Table 2.

Table 2. Common Factors Across Four Studies

1) Sharing Command Responsibility,

2) Value of Communication and Teamwork,

3) Recognizing and Managing Stressor Effects,

4) Assertiveness, or Willingness to Voice Disagreement.

All four studies combine the basic items into composite index scales to obtain more stable indicators of underlying concepts. Such indices permit a more detailed assessment of the separate but related attitudes than a single total score for the entire questionnaire, but they also provide more accurate and reliable results than are available from each of the individual questionnaire items alone.

Gregorich[6] et al. eventually reduced their set from four to three composites by dropping the fourth factor. Sherman, on the other hand, found that fourth factor to be much more robust in his sample of Air Traffic Controllers, and he titled it "Advocacy and Assertiveness."

A confirmatory Factor Analysis was undertaken with the maintenance data initially obtained from an earlier maintenance questionnaire (i.e., the CRM/TOQ.[22]) Results for the items drawn from the CMAQ were similar to those of Gregorich,[6] et al., and with Sherman's subsequent study.[17] As in Sherman's study, the CRM/TOQ's fourth (assertiveness) composite was statistically strong, and was therefore retained as the reflected index "Willingness to Voice Disagreement." Subsequent studies testing the instrument using maintenance personnel also confirmed the four-factor model[1,26] and have labeled their fourth factor "Assertiveness." It is noteworthy that the assertiveness attitude scale has be found to be a particularly robust predictor of subsequent maintenance performance.[28,29]

Measurement Of Attitudes In The Present Study

The MRM/TOQ developed for the present study is a further modification of the earlier CRM/TOQ tested and used in a large- maintenance training program.28 The MRM/TOQ followed the successful format set by its predecessors, in that it is a short questionnaire, yet having enough items to provide convergence to a smaller, easily used, set of concepts.

The basis of the present MRM/TOQ is 25, 5-category, multiple response items which are combined into six composite scales.. In addition to the 14 items now comprising the four attitude scales described in Table 2, an additional eleven opinion items are included in the MRM/TOQ. Six of the eleven deal with communicating and sharing goals within and between work units. This goal sharing scale has been previously developed and tested in prior studies.1,22,26 The five remaining items measure various aspects of the maintenance safety awareness in the company. These safety awareness items are drawn from later versions of the University of Texas CMAQ survey instrument. All six MRM/TOQ scales are shown in Table 3.

The individual item numbers in Table 3 correspond to the numbering of the sample questionnaire found in Appendix A. A "reflected" scale means that the scoring of individual responses for constituent items comprising that scale are reversed (i.e., 1=5, 2=4, 4=2, 5=1) before the scale averages are calculated

Table 3. Scales Used to Measure Human Outcomes of MRM Training

MRM/TOQ **SCALE**	**CONSTITUENT ITEMS** **(See Appendix A)**
Attitude Scales	
Sharing Command Responsibility	6, 8, 11, 13 (reflected)
Communication and Teamwork	12, 14, 15, 16
Managing Stress	9, 17, 18
Assertiveness	1, 2 (reflected)
Opinion Scales	
Communicating and Sharing Goals	20-26

Company’s Safety Awareness	3, 4, 7, 10, 19

All MRM/TOQ surveys also include several questions to collect demographic data, or information about respondent background. These questions include years with the company, years in present job, age, gender, education, job title, department, and shift. Appendix B contains descriptive statistics for the demographic data from all surveys reported here

Finally, all MRM/TOQ surveys administered subsequent to the training include three more multiple response items that are used to measure enthusiasm for the training, and several open ended (or “write-in”) questions measuring intention to change, and self-reports of changes made as a consequence of the training. Each company participating in the present study is welcome to make modifications in the MRM/TOQ either in customizing the format and/or in adding other questions. The MRM/TOQ surveys are printed and administered by the participating companies themselves. The resulting completed surveys were forwarded to the University of Southern California for data entry and processing.

Measurement Characteristics of the MRM/ TOQ

Both reliability and validity of the separate items and the composite scales have been tested -- using maintenance management, and AMTs -- and they demonstrated good measurement qualities.[22,26]

FIVE USES OF THE MRM/ TOQ

There are four versions of the MRM/TOQ questionnaire, which were used in five different ways in the present project.

1. "Baseline MRM/TOQ Questionnaire"

In February-March, 1997, a baseline questionnaire was mailed by Co.D. to a random sample of 800 drawn from all of their maintenance personnel. Recipients were asked to complete the surveys and return them directly (in envelopes provided) to the University of Southern California. This baseline survey measures attitudes and opinions before an MRM intervention is begun. The form of the baseline questionnaire is identical to the "pre-training" Questionnaire described below, and like all versions of the MRM/TOQ it includes eight employee background items. Because all the questionnaires used in this present study are based on the MRM/TOQ core questions the results can be compared across time for one company as well as between participating companies.

The 800 recipients of the Baseline Questionnaire represented a random sample of 10% of the total Co.D. maintenance workforce, managers, supervisors, and assistant supervisors in the company. 399 questionnaires were returned for response ratio of 50%, which is a reasonable response in such cases.

The results of this baseline assessment of management, support staff and AMT attitudes and opinions were processed using standard statistical treatment to describe the characteristics and summary results were returned the company in mid-1997. Those descriptive data included response frequencies for each of the 26 individual items, and intercorrelation of those items and the background questions, as well as mean scores of the six MRM scales described above. The mean scores form a profile that describes the MRM awareness of that air transport maintenance organization.

The Co.D. training developers could use these baseline results to assess the profile of Co.D. in order to modify the design of the MRM training content and curriculum currently under development by the company. Co.D. training designers compared their company's profile against baseline data collected in previous studies, as well as with subsequent "pre-training" survey and the comparable questions' mean scores from those former studies.28 This comparison can aid understanding of which parts of a planned MRM course should be emphasized in order to strengthen weaknesses revealed by the profile.

The baseline survey for Co.D. can also be used to examine the relationships, by work unit, between attitudes before training and maintenance performance.

2. "Pre-training MRM/TOQ Questionnaire"

Pre-training questionnaires were completed immediately before training sessions in Company A. As described above, Company A has two programs progressing simultaneously -- one for AMTs and another for Engineers. Both of these programs had been underway for about six months before this MRM assessment program was introduced. Thus the pre-training MRM survey has not been used with all participants. Some 350 engineers (of a total of some 700) had already attended MRM training before measurement began and likewise about 1,300 AMTs had attended the MRM course prior to the onset of this measurement program.

In 1997 some 110 Company A Engineers attended their four-hour MRM training and were asked to complete a pre-training survey. These questionnaires were sometimes distributed immediately before the two hour training began, and sometimes the questionnaires were mailed to participants several days prior to the date of their scheduled training. The actual practice in this case was that surveys were mailed to participants for about half the sessions, and the other half received questionnaires at the beginning of the session. A smaller than expected overall ratio of 82% completed pre-training surveys was obtained for the Company A Engineering group.

When pre-training surveys are distributed in class, the normal return rate is between 90-95%. The deviation from 100% in such cases comes from two sources. First, the training facilitators (who distribute and collect the questionnaires) are advised to emphasize that the survey is strictly voluntary and confidential. Because it is voluntary, then it is normal that a small fraction of all trainees will choose not to complete the form. More usually the shortfall from 100% return comes from participants who arrive to the training a little late in the session, after the others have completed their surveys.

In the present case, the practice of mailing the pre-training surveys to participants in advance of the course was unique in the Engineering program. Using that method it is not unlikely that participants may forget to complete the survey, or they may complete it and forget to bring it with them to the training session.

With the Company A AMT training, slightly over 3,800 participants attended the two day MRM training between mid-December 1996 and September 1997. In this case facilitators asked all those attending to complete the pre-training questionnaires at the beginning of the session. By the middle of September, 1997, a total of 3,495 completed Co.A AMT pre-training surveys were received, for a return rate of 92%.

In all cases, the pre-training attitudes are compared with “post-training” attitudes immediately after the training, as well as with attitudes measured months later.

3. "Post-training Questionnaire"

The post-training survey was completed by participants at each workshop's conclusion. Data from the post-training MRM/TOQ are sent to the University of Southern California where they are processed and compared with the pre-training questionnaire data. The post-training questionnaire includes the same 26 attitude and opinion items and the eight background questions as the baseline and pre-training questionnaires. In addition, the post-training questionnaire (and all follow-up surveys described below) contain three more multiple response items that are used to measure enthusiasm for the training, and several open ended (or “write-in”) questions some of which ask respondents to evaluate the training content; and others of which measure intention to change, and self-reports of changes made as a consequence of the training. These latter behavioral descriptors will be further described below.

Post-training surveys are distributed and completed in class and the normal return rate is between 90-95%. Like the pre-training surveys, the deviation from 100% in such cases comes from two sources. The training facilitators emphasize that the survey is strictly voluntary and confidential. Because it is voluntary, some fraction of all trainees will choose not to complete the form. Often, however, the shortfall from 100% return comes from participants who need to leave the training early on the second day.

For the Company A AMT MRM program some 3,280 completed surveys have been returned for training conducted through September 1997 (86% return). For the Company A Engineering MRM program, 108 completed post-training questionnaires were returned (98% return rate).

4. "Follow-up MRM/TOQ Questionnaires"

A questionnaire form similar to the post-training instrument is sent to participants in the months following their initial training. Although the time period can vary, these follow-up surveys are designed to be collected 2, 6, and 12 months afterwards. In the present study these follow-up surveys were all identical in form, they measured the respondents' thoughts, assessments, and attitudes over increasingly lengthy periods from the training.

An example of the MRM/TOQ follow-up questionnaire is included in Appendix A. This questionnaire is the basis of all surveys that were conducted by mail in Companies "A," "B," and "C."

In Company A, the AMT training facilitators have sent follow-up surveys out to participants two months and again six months following their training. Respondents are provided a pre-addressed company mail envelope with which to return the questionnaires to the facilitator, or to the central training coordinator, where they are forwarded to the University of Southern California for processing and analysis. The Company A Engineering MRM program did not conduct follow-up surveys during 1997.

A total of 253 6-month follow-up surveys and 556 completed 2-month follow-up surveys were received from Co.A AMTs through September 1997. A conservative estimate of the follow-up survey return rate was accomplished by basing the percentage calculation on the total numbers of pre-training surveys returned six months and two months prior to September 1997. These estimates are the maximum number of training participants for whom the 6-month and the 2-month follow-up surveys would be appropriate. This estimated maximum training participation rate, up to March, 1997 is 828 for six months; and by July 1997, is 2728 for the period two months prior to September. Using the actual returns with these numbers, the return rate calculations s are 30% and 20% for 6-month and 2-month surveys, respectively.

But those lower-bound estimates may under represent the actual return ratios by an unknown amount -- for the following reason. As noted earlier, Company A uses over 20 AMT MRM training sites and some 60 training facilitators. Each site team is responsible for the administration of the MRM/TOQ follow-up surveys (i.e., mailing them out as well as receiving them back). Record keeping for the follow-up surveys is not standardized across the sites and thus its accuracy and vigilance may vary among them. It is possible, in some sites, that follow-up surveys were not sent to all appropriate former training participants. This does not imply that return rates are necessarily higher in all Company A sites -- in fact some site facilitators assess their own site's return rate as low as 10%.

5. Use Of The "follow-up" MRM/TOQ As A Stand-alone Survey Instrument

Companies A, B and C had begun their MRM training before planning to use the MRM/TOQ surveys. In the case of Company A, the AMTs' MRM program had been underway for about six months before the MRM/TOQ was introduced. In that period about 1,300 AMT participants had attended the training. The Company A facilitators decided not only to begin using the pre-training and post-training in December 1996, but they also agreed to send out MRM/TOQ questionnaires to previous participants. It was decided that these past participants would be asked to complete either a "six-month questionnaire" or a "two-month questionnaire." The questionnaires used were identical to the "follow-up" instrument in Appendix A. Those questionnaires received back act as a stand-alone, post-hoc survey of MRM attitudes, opinions, self-described behaviors, and future intentions to use the training. To distinguish these stand-alone 2-month and 6-month surveys from the "follow-up" surveys -- which are mailed to participants who had earlier been asked to complete pre-training and post-training surveys in the training session -- they will be referred to as the "2-month AMT Survey," and "6-month AMT Survey."

In the Company A AMT MRM program many "2-month Surveys," and "6-month Surveys" were sent to past participants by the training facilitators during January 1997, but the exact numbers actually mailed are unknown. 145 "2-month Surveys," and some 250 "6-month Surveys" were received back by the March-April 1997 timeframe. This represents a lower-bound return rate of 23% [(145 + 250)/1,300].

The two Companies, "B" and "C," had both completed their MRM training before the MRM/TOQ core survey could be used. The Training consultant who had delivered the training to both companies mailed a version of the MRM/TOQ to Co.B approximately six months after their training, and sent surveys out to Co.C 12 months after the training.

Company B is a small aviation repair station in the United States (U.S.), which trained all of its 45 maintenance employees during early 1997 using the HPIM model. Although pre-and post-training surveys were not used, Co.B. did complete their one (and only) “6-month Survey” in June, 1997. Total Co.B surveys received back was 44, for a return rate of 98%.

Company C is also a small U.S. aviation repair station where the external training consultant provided an HPIM-based, two day training course for all of its maintenance staff (N=35). For Co.C, that training occurred in mid 1996. The “12-month Surveys” were sent to participants in May and June 1997. Twenty-one surveys were received from Co.C, for a return rate of 60%.

MEASURES OF INTENTION TO CHANGE AND SELF-REPORTS OF CHANGED BEHAVIORS IN THE MRM/TOQ

An open ended (or “write-in”) question about anticipated behavior was included in the post-training survey (Appendix A, Q 30). That question asked, "How will you use this training on your job?" It is included in the survey to measure respondents’ expectations or intentions to behave differently as a result of the MRM training.

That question, and another, asking, "What changes have you made as a result of the training?" (Appendix A, Q 29) were included in all follow-up in questionnaires. That second question is included to measure self-reported behaviors.

The written answers from both the intended behaviors and the self-reported behaviors questions were carefully reviewed, by three judges, to determine commonality of response from which coding categories could be constructed. This review process resulted in some 14 categories derived jointly from answers to both questions. Table 4 presents the list of coding categories derived from that initial analysis.

TABLE 4. Categories For Answers to Open-Ended Behavior Questions	
1. Fight complacency, being more thorough and careful	8. "Communication"
2. Paying more attention to safety	9. Being a better listener
3. Being more aware of myself and others	10. Being more assertive
4. Being more aware of the situation around me	11. Using all the MRM ideas
5. Interacting more and/or better with others	12. Making no changes

6. Applying what I know about "chain of events"	13. Misc. positive comments
7. Applying what I know to counter the "dirty dozen" list	14. Misc. negative comments

A final write-in question asked respondents to describe what they thought were the best features of their MRM training (Appendix A, Q 31). This question can be used as another measure of enthusiasm for the course and the program.

Summary of Questionnaires Returned

Table 5 presents the total returns for the five surveys reported here. Estimates of return rates are shown in the second column.

TABLE 5. Sample Size And Response Ratios:
Surveys in Five Companies' MRM/TOQ Questionnaires Received by 9/1997

SURVEY	TOTAL RETURN	RETURN RATE
1. Co.D Baseline Survey	**399**	**50%**
2. Co.A Engineer pre-training Survey	**88**	**82%**
3. Co.A Engineer post-training Survey	**108**	**98%**
4. Co.A AMT pre-training Survey	**3,495**	**92%**

5. Co.A AMT post-training Survey	**3,280**	**86%**
6. Co. A 2-month follow-up Survey	**556**	**20%***
7. Co.A 6-month follow-up Survey	**253**	**30%***
8. Co. A, 2-month Survey	**147**	**23%****
9. Co.A, 6-month Survey	**154**	**23%****
10. Co.B, 6-month Survey	**44**	**98%**
11. Co.C, 12-month Survey	**21**	**60%**

*** Possible underestimate, because it assumes surveys were actually sent to all appropriate participants.**
**** Estimated using data from both 2-month and 6-month surveys combined for overall return rate and also assumes surveys were actually sent to all prior , original participants.**

As described above, the highest return rates for the Pre -training surveys result from participants who are asked to complete the questionnaires while they were present in the training sessions. Return rates for the "baseline" survey and the subsequent "follow-up surveys" are lower because they are the result of surveys conducted by mail. In prior studies baseline return rates were 50% for maintenance managers and 67% for AMTs. Compared with these, the return rate for Co.D. is within expectation.

On the other hand, the Co.A return rate for the **follow-up** surveys may be higher than estimated. The somewhat crude and rather conservative estimates of return ratio for Co.A follow-up surveys were described earlier. Those return rates are 20% for 2-month, and 30% for the 6-month surveys. In actuality, those rates may be only slightly lower than the 25%-37% return rates reported over three years in an earlier study,28 but those were lower than desired as well. During the first year of that earlier study, the follow-up survey return rates were higher, ranging from 40%-45%.24

Testing MRM/TOQ Attitude Scale Independence

The quantitative questions in the MRM/TOQ were designed to obtain four independent attitude scales (*cf.*, Table 2) and two opinion scales, all specifically sensitive to MRM training curricula. Individual participant's responses in each of the five program samples were examined to compare the intercorrelations among the four attitude and the two opinion scales. Those five intercorrelation tables are located in Appendix C. The patterns of intercorrelations are largely replicated among the program samples. These results demonstrate that the four MRM attitudes ("Communication and Teamwork," "Sharing Command Responsibility," "Stress Management," and "Assertiveness") have lower correlations among them, and thus are largely independent of one another (a desirable condition); and that they are also little related to the two opinion scales. If anything, there is a slight tendency for most attitude scales to be inversely (if only modestly) related to the opinion scales. In four of the five samples, the two opinion scales, "Goal Sharing" and "Safety Awareness," are quite highly related to one another. This association in opinions may suggest the presence of a "halo" effect regarding respondent's views of their organization -- if they feel positive about one aspect of their employer, supervisor, and workmates they may also report feeling positive about other aspects.

MEASURES OF AIRLINE PERFORMANCE

Company A has provided monthly statistics for Occupational Injury, Aircraft Damage and Facilities Damage for the years of 1995, 1996 and 11 months of 1997. In principle these incident counts are reasonable measures of safety performance. The total of all 3,250 AMT respondents in the post-test Company A sample, includes the members of over 90 organizational units drawn from many parts of maintenance (base maintenance, line maintenance, shops, quality, and stores). The total numbers of units in each analysis vary depending on the specific performance indicator, because not all the work units are measured on the same performance, nor are the same units always reported every month. Table 6 shows the range of numbers of work units available for each of the three measures available monthly over the 1995-97 period.

TABLE 6. Sample of Work Units Available for Performance Measures Company A AMT Study

Performance Measure	Number of Work Units
Lost Time Injuries (LTI)	• Line Maintenance Stations: 3,* 36-39 • Base Maintenance Units: 20-21 • All Sites in Sample: 41-90
Ground Damage-Aircraft (GD-A/C)	• Line Maintenance Stations: 3,* 5,* 7-18 • Base Maintenance Units: 0-2* • All Sites in Sample: 3, 5-23
Ground Damage-Facilities (GD-Fac)	• All Sites in Sample: 0-4*

*** Any months with five or fewer work units reporting are excluded from further analyses**

Co.A Lost Time Injuries

The injury rates are expressed in terms of the number of injury incidents which result in days lost to treatment and recovery (termed Lost Time Injuries, or "LTI"). The AMT MRM training undertaken by Co.A .is expressly intended to reduce LTI, and time is spent at the conclusion of each two-day session in reviewing an injury case and discussing ways to avoid such cases in future. LTI data are available by maintenance cost center by month. There are some 90 Company A cost centers reporting LTI from which personnel attended the AMT MRM training by the end of September 1997.

Aircraft and Facilities Damage Statistics for Co. A

Monthly counts of maintenance-related aircraft damage, and damage to airline and airport facilities are also available for 1995, 1996 and part of 1997. The number of cost centers reporting damage incidents are much smaller than those for LTI, not exceeding 23 for aircraft damage and only a maximum of four cost centers for facility damage.

Facilities damage data are not examined in the present document because the very small number of work units (cost centers) reporting such results precludes the use of reliable statistical analysis.

Company D Paperwork Errors

Logbook errors as well as total paperwork errors per line station per month have been made available from January 1996 through July 1997 in Company D. Actual flight departures per line station per month were also provided by Company D and those data were used to control the error statistics by size (i.e., amount of flight activity) per station. Those corrected data for all months of 1996, plus the first seven months of 1997, are totaled by month and plotted graphically. The resulting chart provides for an examination of error trends over 18 months before Company D MRM training begins in January 1998.

Company D, Benchmark Sample

The 399 respondents in the Company D benchmark survey sample draws from throughout the maintenance organization. One of the performance measures available deals only with line maintenance stations. There are a maximum of 40 line maintenance stations for any month in the performance data provided for 1995-1997. Selecting only those survey respondents identifying themselves as working in line maintenance stations amounts to 86 people (24% of the sample).

RESULTS

COMPARISON OF PARTICIPANTS' ENTHUSIASM FOR MRM

We can examine and compare participants' post-training responses to three questions, dealing with their general reactions to the MRM program. One of these questions measured the degree the training increases safety and teamwork (*cf.*, Appendix A, Q 26). The second question asked about the usefulness of the training for others (Appendix A, Q27). The third question measured the training's changes in respondent's behavior on the job (Appendix A, Q28). In immediate "post-training" questionnaires these three questions are worded to measure expectations (e.g., "this training will be useful to others"), and the questionnaires used 2, 6, or 12 months later the three questions are worded to measure actual experience (e.g., "this training has been useful to others"). For Company A, immediate post-training responses from AMTs and the Engineers are compared with the AMT data available from subsequent months, as well as with data from Companies B and C. Figure 1 presents comparisons for the three questions.

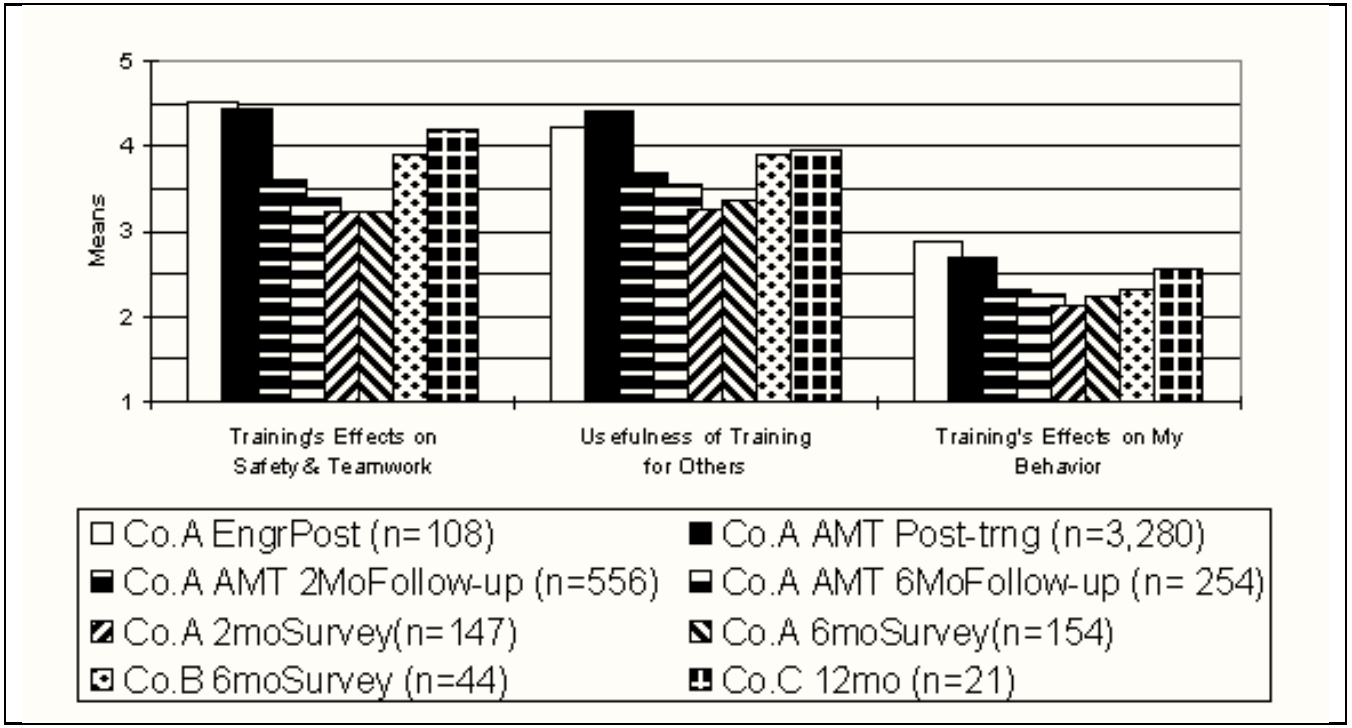

Figure 1. Enthusiasm for MRM Training In Months Following Comparison of Mean Scores

An Analysis of Variance (ANOVA) for independent samples was conducted for each of the three scales in Figure 1 and the resulting "F" statistics were significant ($p<.000$). In Figure 1, the apparently lower scores for the question regarding personal impact are explained by the scale used. Question 28, "How much has the training changed your behavior on the job?" is unique in the MRM/TOQ in that it uses a four point scale (instead of 5-point), so its resulting mean score can never reach the levels of the other two questions in Figure 1.

Figure 1 shows the Company A participants strongly optimistic about the promise of the MRM program immediately after they had experienced it (i. e., post-training).

Figure 1 also shows that Company A surveys taken some months after the training show decidedly less enthusiasm for the general effects of the training. Like them, participants from Companies B and C are also more moderate in their enthusiasm when compared with Company A post-training results, but they also had been away from the training for between six and 12 months. Perhaps the positive energy can dampen with time -- but consider the following. In assessing the personal affect of the training ("Training's effects on my behavior") respondents in Companies B and C are more positive than their Company A counterparts which suggests that the very diminished enthusiasm two months and six months afterward in Company A may reflect program implementation or company culture and past history.

When compared with results reported in earlier maintenance studies, the four samples in three companies presented in Figure 1 all show a slightly lower level of enthusiasm and optimism than either maintenance managers or AMTs studied earlier.29 Furthermore, in Company A, enthusiasm does drop over time. When the Company B and C data are compared with post-training enthusiasm scores from Company A AMT and Engineering samples, as well as with the post-training scores from earlier studies24, their diminished scores could also be explained due to the passage of time. (This pattern of MRM enthusiasm diminishing over time has been observed in unpublished data obtained from that 1991-94 study.)

Previous studies using data from maintenance managers and from Flight Operations in other companies24 and AMTs elsewhere29 show that regardless of the variant of MRM used, maintenance personnel are always more optimistic about the training's potential effects than their counterpart's in flight operations enthusiasm for their cockpit resource management (CRM) training.

RESULTS USING ATTITUDE AND OPINION SCALES

Comparison Of Companies A, B, & C MRM Response Over Time

Attitude change from pre-training to post-training surveys

Results using all Company A respondents who completed the MRM/TOQ immediately before and immediately after training demonstrated that many of the intended effects on participants' attitudes were achieved. Figure 2 presents the pre- and post-training results for both AMTs and Engineers.

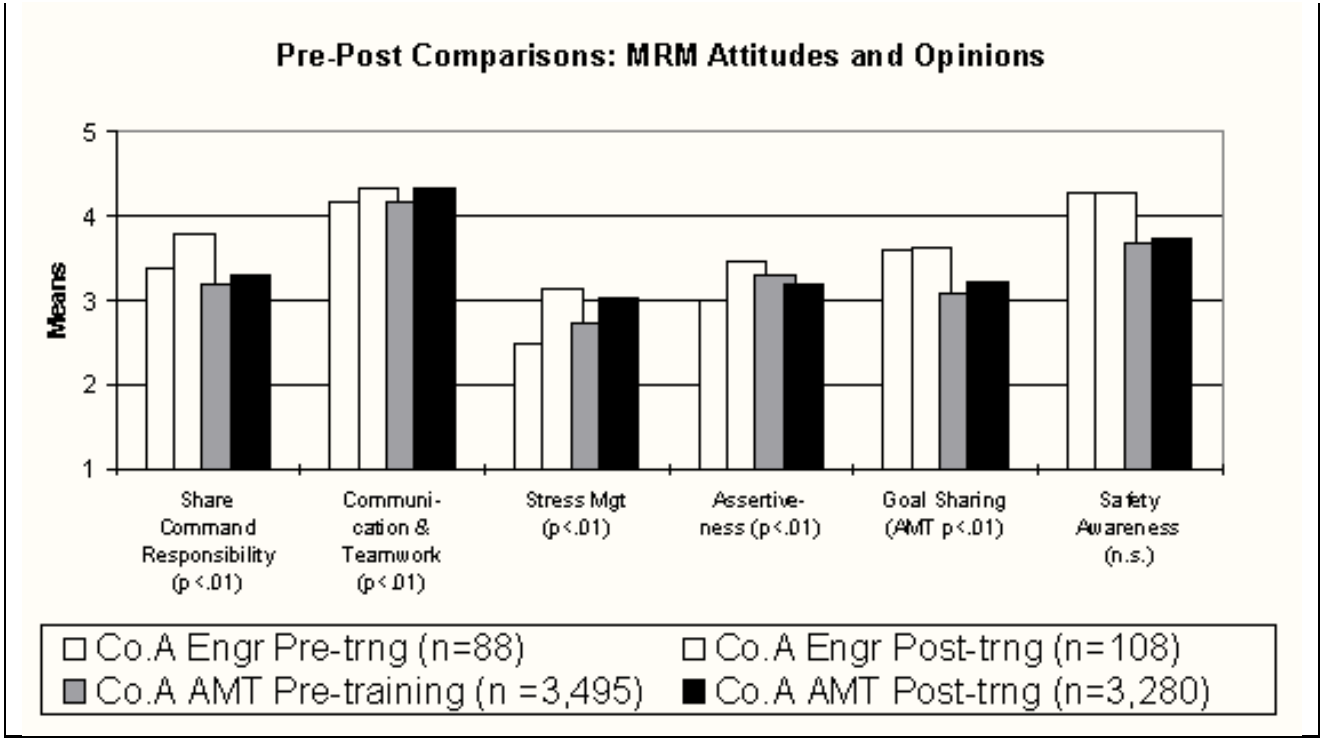

Figure 2. Attitudes and Opinions about MRM-related Topics Immediately Before and After Training: Comparison of Company A Mean Scores

Figure 2 shows that both AMTs' and Engineers' attitudes about participation ("Sharing Command Responsibility"), teamwork ("Communication and Teamwork"), and "Stress Management" all improved (all increases were statistically significant) immediately following the training. In most cases the engineers improvement was greater than that of the AMTs. Indeed for stress management, the engineers began their training feeling considerable more sanguine about the effects of stress and pressure on their decisions than the AMTs and their attitude toward stress managment rose even higher.

A One-way Analysis of Variance for non-independent groups (either Sheffe test, or Dunnet “T3”), plus Pairwise Multiple Comparisons, were used to test the differences among same-scale values for the pre-, and post-training, and 2- and 6-month follow-up samples. Company A surveys and established that the pre-post differences noted in Figure 2 were statistically significant for the AMTs. For the Engineers’ sample, the pre-post differences were significant except for the “Goal Sharing” and “Safety Awareness” scales.

Figure 2 also shows the AMTs' attitude toward assertiveness decreased significantly ($p<.000$), while the engineers revealed a more favorable attitude toward speaking up assertively following training. This is likely to be the direct result of the different emphases the two programs place on assertiveness. It should be recalled that the Company A AMT program closely followed the HPIM training model (*cf.*, Table 1) as did the training conducted in Companies B and C. As noted earlier the HPIM initial program used here does not emphasize assertiveness skills.

Pre- and post-training changes in opinions

In Figure 2 the training shows little immediate impact on Company A AMTs' opinions about their organization's safety awareness. But AMTs' view of goal setting and sharing increased ($p<.000$). Engineers assessed both of these aspects of their organization higher than did the AMTs.

Attitudes And Opinions Following Training

Figure 3 presents the mean scores of the MRM-related attitudes and opinions in Companies A, B, and C for their 2-, 6-, and 12-month surveys. The Company A results are for the AMT program only because the engineering program has not yet conducted follow-up surveys of its participants

Company A results in Figure 3 show virtually no change between two and six month follow-up surveys on teamwork and stress management. There is a statistical increase in feelings about assertiveness between two and six month surveys ($p<.02$). But the six month survey shows no statistically significant changes in opinions about their company's safety awareness and goal sharing.

The same "Sheffe" and Dunnet "T3" statistics noted above were used to test the differences among the same-scale values for the Company A AMT surveys taken subsequent to the training. With one exception, there were no significant differences found among the post-training, two and six-month surveys. That exception is the goal sharing scale, which decreased significantly between the post and 2-month, and the post and 6-month surveys ($p<.04$; .00). There is no immediate explanation for this decrease in opinions about goal setting. Both goal sharing and safety awareness are important aspects of the MRM training and some positive effect should be expected for both.

Company B, surveyed once at six months after training reveals, in Figure 3, a lower attitude toward participation ("sharing command responsibility") than the Company A six-month follow-up. Conversely, Company B's attitude about teamwork is higher than their Company A counterpart. Figure 3 also shows Company B's six month attitudes toward stress management are quite high in comparison with either Company A or Company C. Company B's opinions about safety awareness are also high.

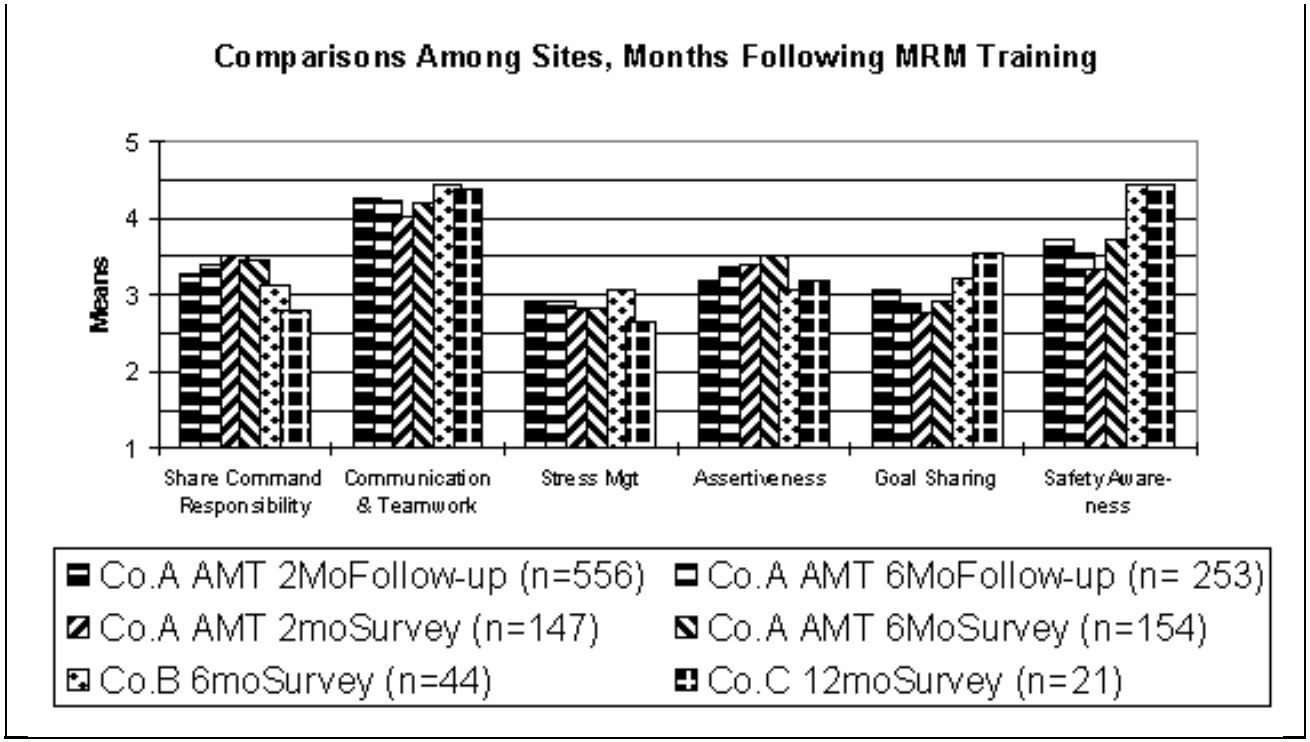

Figure 3. Attitudes and Opinions about MRM-related Topics Surveys 2, 6, and 12 Month After Training Companies A, B. and C; Comparison of Mean Scores

Company C's 12 month results in Figure 3 show the lowest attitudes toward sharing command responsibility, and stress management; and a high attitude toward teamwork, when compared with Company A. Company C's very low stress management mean score is similar to the overconfident Co. D Baseline survey (Figure 4) and the Co.A Engineers' pre-training attitude (*cf.*, Figure 2). With Company B, Company C's opinions about safety awareness are extremely high, and its opinions about goal sharing are the highest in Figure 3.

Baseline measurement before MRM training begins

The baseline scores for the six MRM scales are displayed in Figure 4. Levels for most of the attitude and opinion measures are unremarkable except that stress management and assertiveness are as low as the Engineering pre-training survey results shown in Figure 2. In all cases these baseline results show that Company D's MRM training program will have ample opportunity, because they represent "room to improve" in every case.

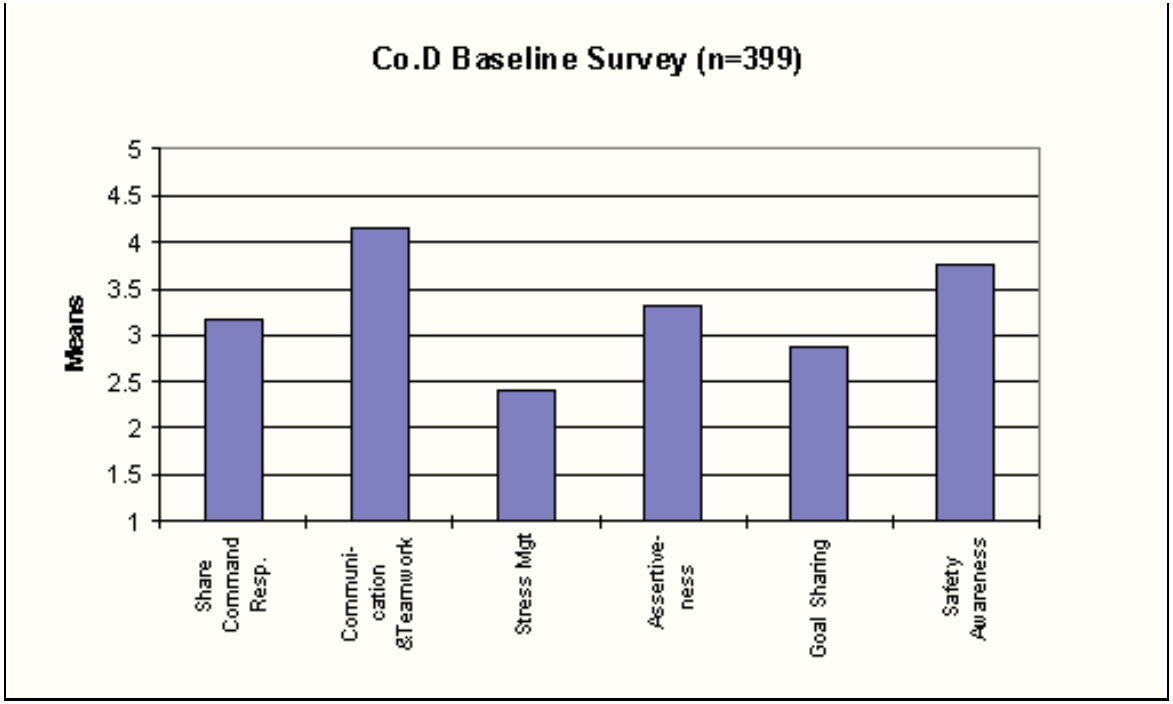

Figure 4. Baseline Survey Attitudes and Opinions about MRM-related Topics

REPORTED BEHAVIOR CHANGES FROM THE MRM TRAINING

One question, included in the post-training survey and in the 2-month, 6-month and 12-month questionnaires, asked respondents to list the personal changes they intend to make following the training. A further question in the 2-, 6-, and 12-month instruments asked respondents to list what changes they actually made as a result of the MRM training.

Intentions to change

Figure 5 presents a summarized selection of the Company A AMT sample's answers to the question, "How will you use the training on the job?" Results in Figure 5 represent the most important and frequently stated answers. Although many other specific answers were given they accounted for smaller proportions of the total [*cf.*, Table 4] and are not included here. For this reason the total percentage for any of the several sites do not equal 100%. For the post training and two-month follow-up surveys, Figure 5 shows that three answers account for a great proportion of the samples studied.

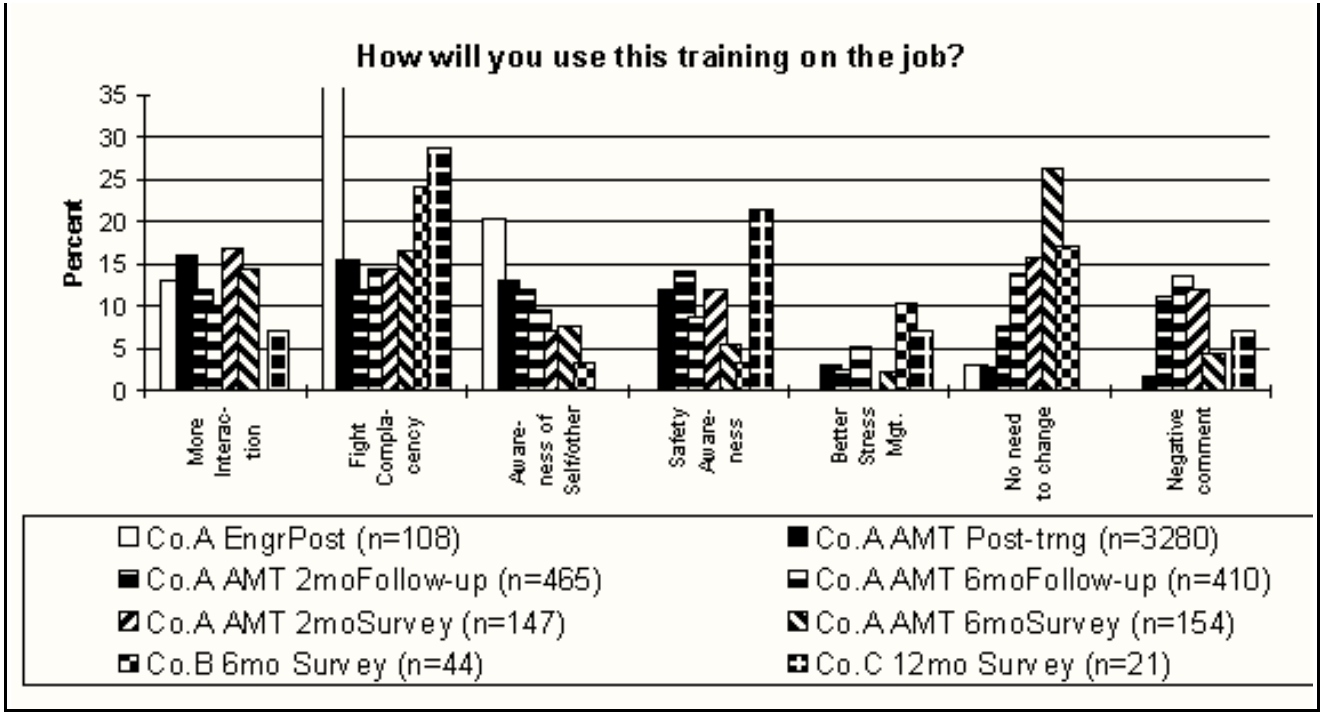

Figure 5

Over 70% of the post-training respondents in the Company A Engineering program said they intended to apply “More Interaction” (or intending to work more closely and cooperatively with others), “Fight Complacency” (or intending to work more carefully), being “More aware of themselves and others.” Nearly half of the Company A AMT sample in the post-training survey say that they expected is use “More Interaction” “Fight Complacency,” and being “More aware of themselves.” Together those four answers totaled 45%. For the 2 month and 6 month follow-up surveys the total proportion drops to nearly one-third (36% and 34% respectively). Those three answers in the Company B and Company C 6 month and 12 month surveys between them also bracket about one-third of their totals (28% and 36% respectively).

In Company A, intentions to change, changed

More important than the drop in those positive intentions is the increase in less positive comments shown in Figure 5. The percentage of respondents saying simply that they didn’t intend to change, or who made a negative comment about the program or its effects on their future behavior, increased dramatically over time. Those two critical responses together account for less than 5% of the immediate post- training responses, but they increase to totals of 19% and 27% in the 2-month and 6-month surveys. This is a four- to five-fold increase in negative outlook with the passage of time. Intentions definitely faded. Looking behind the summaries at what respondents’ actually said, many of the negative comments given, revealed that respondents had tried to change but they were ignored, or not supported, or actually punished when they tried to speak up and become more active.

Reports of changed behaviors

Figure 6 shows that in the months following training, intentions didn't always match results. Although one-sixth of post-training intentions were to increase interaction and communication with others (Figure 5), Figure 6 shows that less than half that number report actually practicing more interaction and communication with others. On the other hand, Figure 6 also shows that reports of working more carefully (fighting complacency) and being more aware of self and others match earlier expectations more closely. These results suggest that early intentions to behave differently with others in the work place may be premature -- that many respondents actually favored new behaviors they could adopt passively and by themselves.

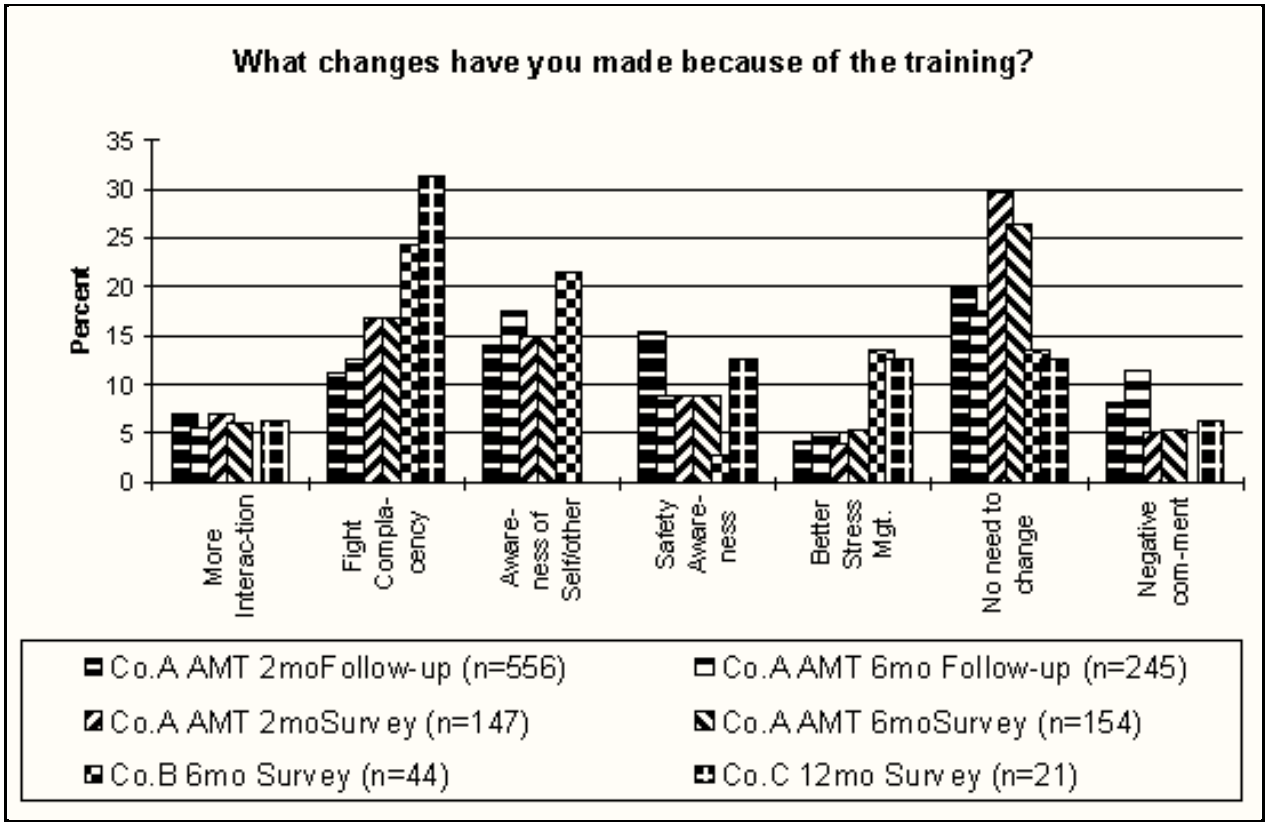

Figure 6

Being thorough, fighting complacency, being aware of one's own impulses and feelings, and watching others, are all useful behaviors that AMTs could do by themselves. But actually speaking up, or initiating work related conversation or discussion with others, is more difficult to do without having AMTs consciously working together to improve that teamwork and interaction in the workplace.

Figure 6 also shows that reports of "no change" and negative comments about changing and/or the effects of the MRM training are quite high for all Company A samples. In fact the combined percentage of "no change" and negative answers approaches 30% for both the 2-month and the 6-month follow-up surveys – and exceeds 30% for the stand-alone surveys. Furthermore, for the follow-up surveys the proportion of negative answers to the more neutral "no change" increases by nearly one-half between 2- and 6-months.

Discussion of the Training and the Changes

This case of large-scale AMT training in MRM shows how timely and appropriate such a course can be. On exiting the course, most Company A's AMT participants are enthusiastic about the course and its content and they are optimistic about its effects on their workplace. However, without rapid follow-through on the course and its lessons, the AMTs experience a fall-off in enthusiasm and begin to show a negative backlash. In fact the only positive indicator of those measures, that shows improvement six months after training is an increased value for "assertiveness" -- including a willingness to disagree with others and to question others' ways of working. Frustrated with slow progress in achieving the promise of the MRM training, a sizable number of AMTs see a willingness to speak up -- perhaps even in anger or with criticism -- as the only path for their energy.

MRM training that becomes "spray and pray," whether by intention or by accident, may sow the seeds of its own discontent. The ideas and behaviors are too liberating to expect participants to see them erode without comment.

AMTs are pushed to the front of what is essentially a culture change, they then wonder where everybody else is -- and then get frustrated and/or discouraged when they don't see anybody else with them. This effect may become more common as custom-built MRM training courses for AMTs are substituted for management and trade union commitment to larger MRM programs which include changes in company policies, safety practices, as well as behaviors and structures which encourage mutual trust and openness.

TRENDS IN MAINTENANCE PERFORMANCE BEFORE AND AFTER THE ONSET OF MRM TRAINING

Company A Safety Performance Trends

In Company A two measures of Maintenance Department performance were used in the present study. These measures were the frequency of lost time injuries (LTI), and the frequency of "ground damage" maintenance-related aircraft damage incidents ("GD-A/C"). Both measures were available by work unit by month for the 24 months of 1995-1996 and the first 11 months of 1997. The statistics plotted in the following charts are average scores for the number of work units reporting performance each month.

For Company A, the monthly performance data are plotted in series "before" and "after" the onset of MRM training. In practical terms the before-training series for line maintenance stations spans the period January 1995 through June 1996. The after-training data series for line maintenance included July 1996 through the most current figures late in 1997. Because base maintenance personnel didn't begin MRM training until much later, the "before" series for that group runs through March 1997. This leaves only eight months of "after-training" base maintenance performance (4/97-11/97) available for this present analysis.

Figures 7 and 9, respectively, present the line maintenance performance trends for Lost Time Injury (LTI) and Ground Damage to Aircraft (GD-A/C). Figure 8 presents the base maintenance LTI performance. There is no comparable Figure showing GD-A/C performance for base maintenance due to the small sample size available for that measure.

Figure 7 shows a downward (improving) linear trend for frequency of lost time injuries (LTI) in line maintenance stations for the 17 months after the MRM training began. That represents a 20% decrease during that 17-month period. This is in contrast to the upward pre-training trend observed over the first 18 months in Figure 7. A reasonable conclusion is that the primary intended results of the MRM program -- in its initial line maintenance target population -- shows a favorable outcome.

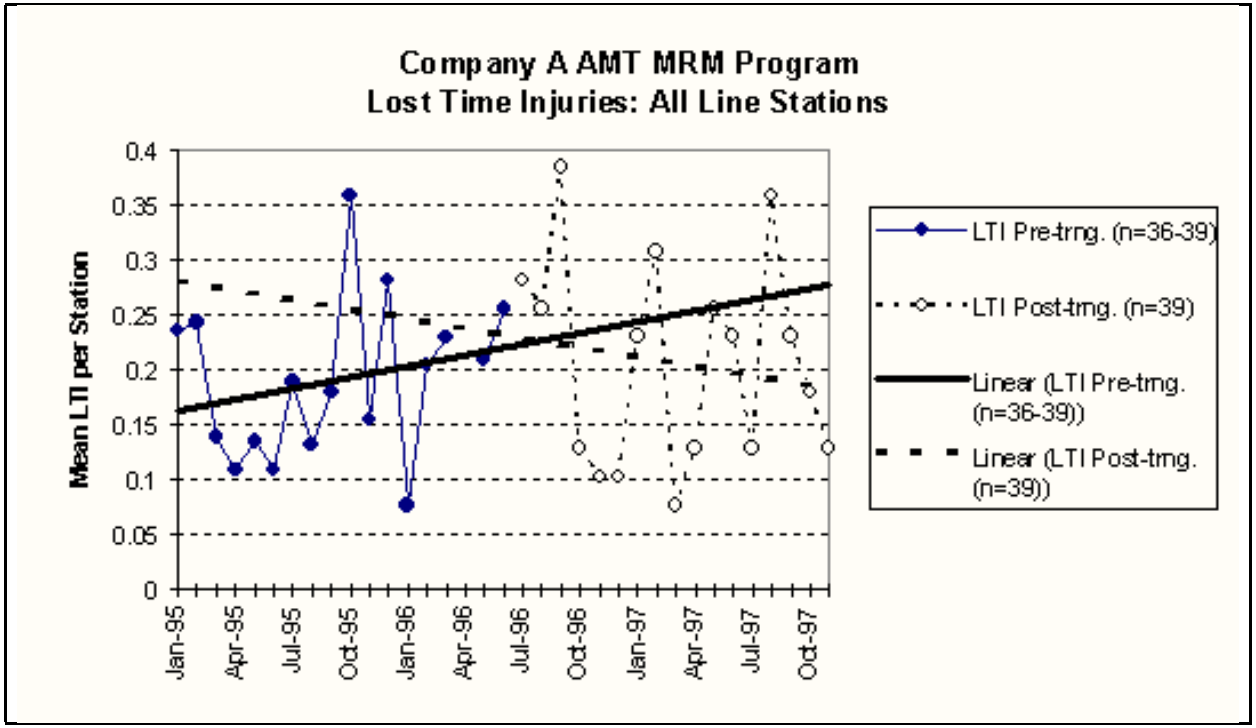

Figure 7

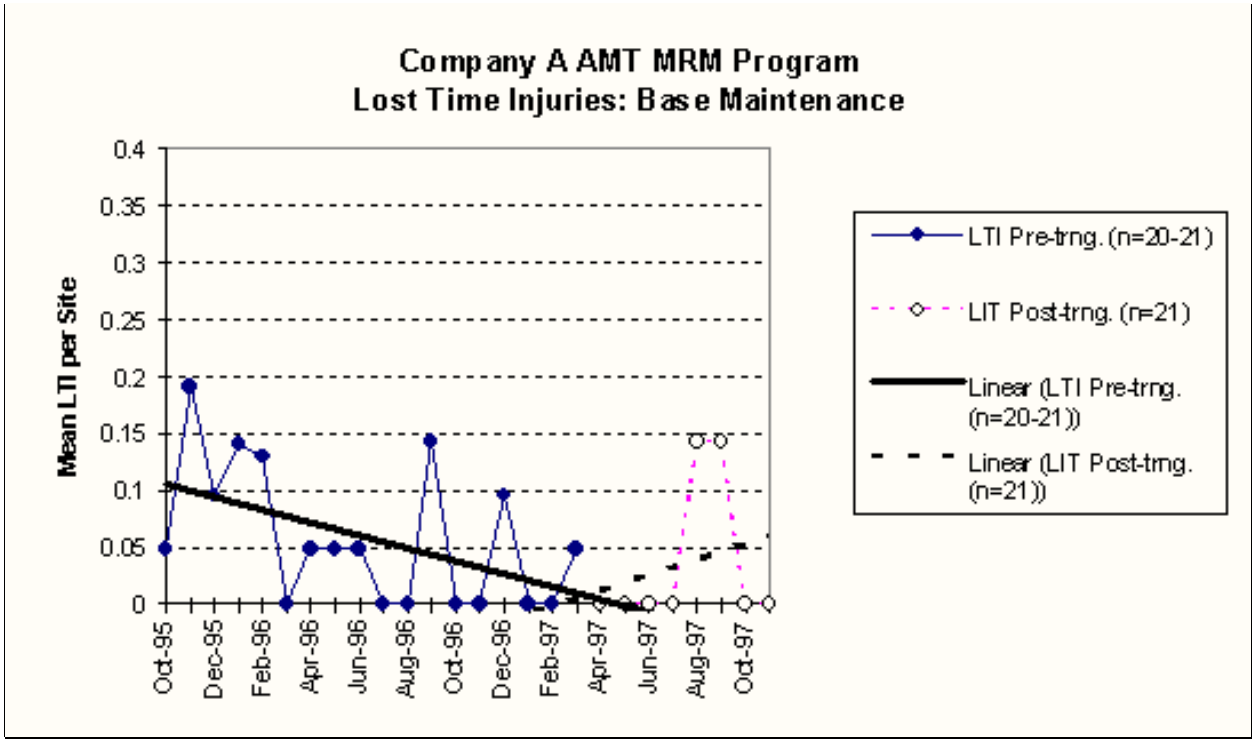

Figure 8

Figure 8 presents average monthly LTI for the base maintenance sample who have completed the MRM training to date. The 18 months pre-training trend shows an improvement (decreasing frequency) in LTI before the onset of base maintenance MRM training. LTI performance over six of the eight post-training months is perfect (zero), although incidents late in the period push the post-training linear trend line in an unfavorable upward slope. The only conclusion possible for this base maintenance sample is that more time is necessary to complete the training in that department and to continue to observe performance over a longer period.

Figure 9 shows line maintenance ground damage performance post-training to have no improvement over the 17 months after the onset of the training. That flat line in GD-A/C however contrasts favorably against the pre-training linear trend of increasing aircraft damage over the 18 months preceding the onset of training.

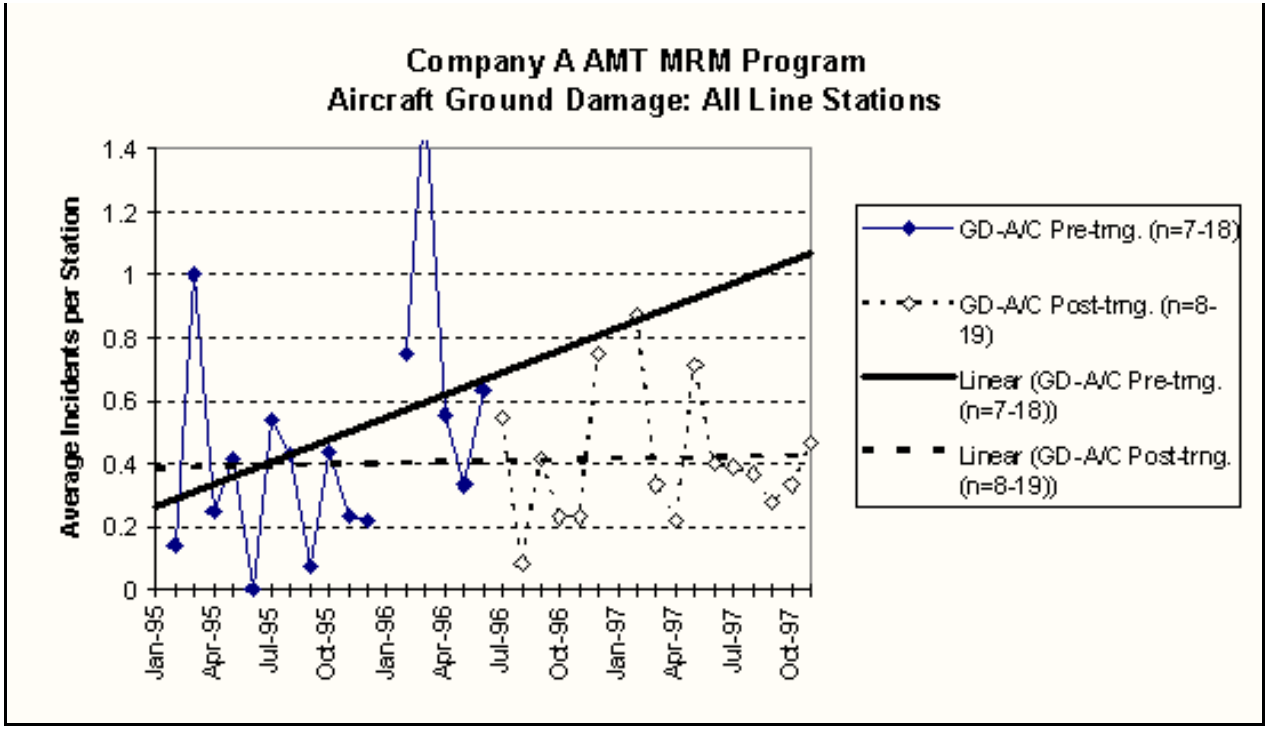

Figure 9

The implication from Figure 9 is that the GD-A/C in line maintenance stations seems to stabilize at a lower level (0.4 incidents per stations per month) after the onset of the MRM training. The ample number of months with performance lower than 0.4 incidents suggests that room for continued improvement exists for ground damage.

Company D Error Performance Trends

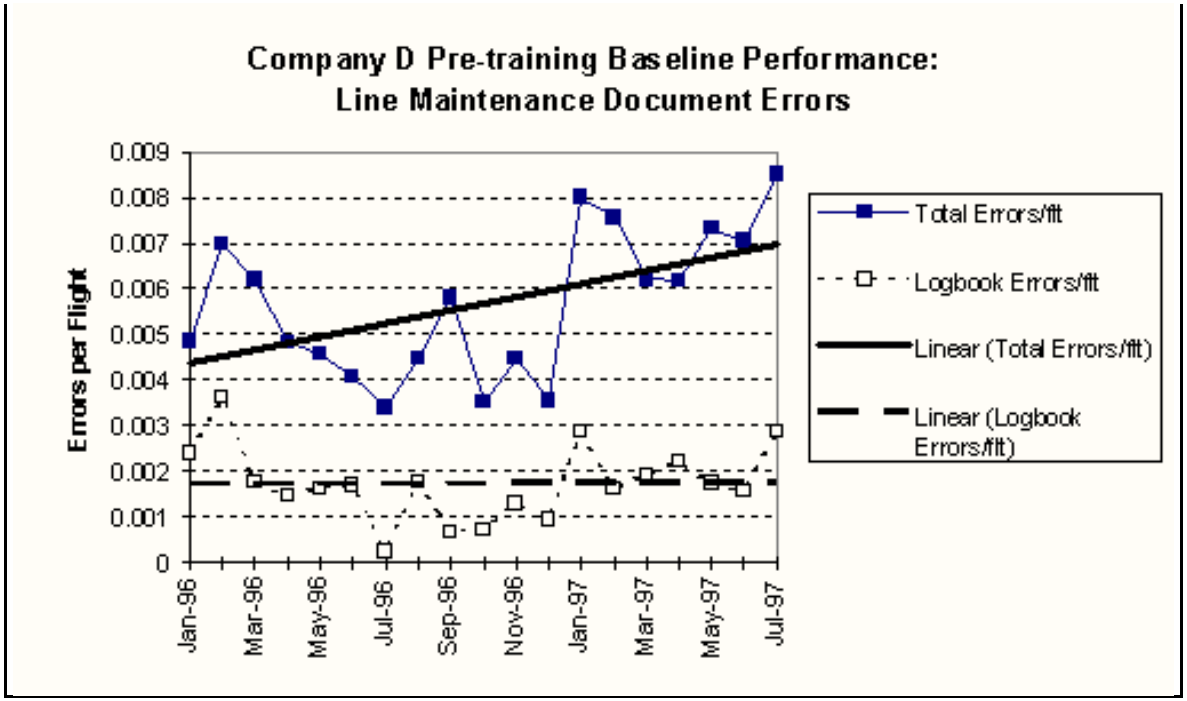

Figure 10

For Company D paperwork error performance data include Logbook errors, as well as all paperwork errors per line station, per month for 18 months. Figure 10 plots both measures for a Company D "baseline."

As Figure 10 clearly shows, the linear trend for Logbook errors remains stable and low (less than 2 errors per 1,000 flights) and can be used as a "benchmark" for comparing future effective performance. On the other hand, Company D's total paperwork error trend in line maintenance stations shows a dramatic increase over the 18 month period plotted in Figure 10. There appears to be ample opportunity for reducing document errors that MRM training may be able to address.

Testing Relationships Between Attitudes and Performance

A most important result is whether the attitudes and opinions affected by the MRM training are, in turn, a cause of subsequent and expected performance outcomes. This effect can be tested by correlating the safety performance of maintenance work units with the attitudes of their members. To accomplish this the performance results must be available for a sizable number of work units over a fairly long time period and the post-training attitudes of work unit members must be combined into scores of each group's average attitudes. These conditions could be met in the present study using the Company A AMT data set.

The correlation statistics used in the present analysis

The relationships between the attitude indices and the performance measures, as presented in Tables 7 and 8, were calculated using the Pearson Product-Moment Correlation statistic (“r”), or the Spearman Rank-order Correlation statistic ("Rho," or ρ) when the data points (more correctly degrees of freedom) are less than 30. The use of Rho is advisable in that case because the characteristics of small data sets narrow the analytic power of most other statistical tests. This analysis is treated as descriptive, not predictive, thus 2-tailed tests of significance are used.

In order to simplify the analysis in this first year of the present study the 35 months of Lost Time Injury (LTI), and Aircraft Ground Damage (GD-A/C) performance data were clustered into six month groups and average scores were calculated. Thus average safety performance scores were created for the six periods: January-June 1995, July-December 1995, January-June 1996, July-December 1996, January-June 1997, and July-November 1997. These six performance periods were correlated with the six MRM attitude and opinion scales (*cf.*, Table 3), averaged by AMT work units, from the pre-training and post-training surveys, as well as from the 2 month and 6 month “follow-up” and “stand-alone” surveys. The correlation analysis revealed that neither the pre-training attitudes nor the immediate post-training attitudes were significantly correlated with safety performance before or after the onset of training. The degrees of freedom for correlations between the stand-alone surveys and performance were generally too small to pursue further or to report here. To simplify the present discussion of the overall correlations analysis only the correlation coefficents from the analysis of the two-month follow-up survey, are presented in Tables 7 and 8 for further discussion here.

The measured results of the two performance measures, Lost Time Injury and Aircraft Ground Damage, are “improving” when they decline numerically (i.e., the absence or lowering of occupational injuries and/or ground damage incidents). To keep the presentation of findings consistent all results in Tables 7 and 8 are described as negative coefficients when the correlations are in the expected direction (i.e., favorable attitudes equal better subsequent performance). Predictions about the effects of prior performance on subsequent attitudes were not made. The two month follow-up survey showed a number of interesting and expected correlations with both safety measures.

Table 7 and 8 present the correlations between the two month follow-up attitudes and opinions and performance. Those two months surveys were completed between March and September 1997. The unit performance data in Table 7 range from 24 months before the 2 month follow-up survey results to a few months after.

Table 7 contains relationships with lost time injuries (LTI). Three of the significant correlations in Table 7 are with the “Stress Management” scale – one correlation (Jul-Dec ’95) is with LTI performance 18 months before the survey, another correlation (Jul-Dec ’96) is some six to 12 months before the survey, and the third significant correlation is with performance in Jan-June 1997, which is roughly coincident in time with the survey. All three are negative coefficients indicating more favorable attitudes toward stress management are related to lower injury rates. This MRM-related attitude, two months after the training, is favorably related to LTI.

TABLE 7. Correlation coefficients between Company A AMT MRM/TOQ Attitude Scales (2mo Follow-up Survey), and Maintenance Performance: Line and Base Maintenance

LOST TIME INJURY

Jan-June ’95 (n=39 work units)	July-Dec ’95 (n=41 work units)	Jan-June ’96 (n=15 work units)	July-Dec ’96 (n=40 work units)	Jan-June ’97 (n=40 work units)	July-Nov ’97 (n=40 work units)

1. Share Command Responsibility	**-.05**	**-.10**	**-.14**	**-.12**	**.02**	**.10**
2. Communication & Team-work	.05	-.04	.04	.10	-.04	-.07
3. Manage Stress Effects	-.31	**-.37***	-.45	**-.45****	**-.39***	-.21
4. Assertiveness	.12	.21	.26	.20	.21	.26
5. Goal Sharing	.24	.21	.35	.18	**.36***	.18
6. Safety Awareness	.07	.01	-.05	-.04	-.03	-.07

On the other hand, the Goal Sharing scale shows one positive (+) relationship with LTI, during the first half of 1997. That period, roughly coincident with the 2 month follow-up survey, was not expected to be positive. A positive coefficient here means that positive opinion about goal sharing and attainment in the work unit and with others, in mid-1997, is related to high injury rates in those same units at that same time. It is only one occurrence in Table 7 and it cannot be explained from information presented here. Understanding that effect must await further analysis.

Table 8 shows the correlations between the two months follow-up attitudes with aircraft ground damage. The correlations between the two month follow-up survey and ground damage incidents for January-June 1995, 1996, and 1997 have degrees of freedom (derived from the number of work units available for those correlations) which are extremely small. Those correlations will only be used in conjunction with other findings, where applicable.

TABLE 8. Correlations between Company A AMT MRM/TOQ Attitude Scales (2mo Follow-up Survey), and Maintenance Performance: Line and Base Maintenance

GROUND DAMAGE

	Jan-June '95 (n=4 units)	**July-Dec '95 (n=10 work units)**	**Jan-June '96 (n=3 work units)**	**July-Dec '96 (n=9 work units)**	**Jan-June '97 (n=3 work units)**	**July-Nov '97 (n=13 work units)**
1. Share Command Responsibility	**.59**	**.49**	**-.96**	**.57**	**.19**	**.05**
2. Communication & Team-work	-.93	-.54	.94	-.17	.91	.12
3. Manage Stress Effects	**.99****	.32	-.70	-.22	-.46	**-.60***

4. Assertiveness	.33	-.09	.84	.16	.88	.27
5. Goal Sharing	-.49	-.28	.67	.41	.90	**.60***
6. Safety Awareness	-.46	-.37	.87	-.25	.86	.11

In Table 8, as in Table 7, it is the stress management scale that shows the significant relationships with safety. In this case, the correlation coefficient with ground damage data 24 months ahead of the survey is positive, meaning that higher damage incidents reported for work units in early 1995 are related two years later to 2 month follow-up surveys with more favorable attitudes toward stress management. This effect was not anticipated, the number of work units is very small (df=4), and no reasons for it can be offered at this time. The other significant correlation with stress management in Figure 8 is in the last half of 1997 – the period coincident with, and following, the survey results. This correlation is expected, and suggests that favorable stress management following the MRM training is related to subsequent good ground damage performance. In other words, the good attitudes may lead to the good performance. The third statistically significant correlation in Table 8 is between the Goal Sharing scale and ground damage in the last half of 1997. As with the goal attainment correlations in Table 7, this coefficient is positive. This result deserves further examination in order to understand or explain it.

DISCUSSION

The Role of Stress Management in MRM

In Company A the pre-training and post-training comparisons clearly show that the MRM program had an impact on feelings about managing stress (Figure 2). Although those reported feelings do appear to fall back a little in the months following training the decreases are statistically non-significant. Understanding and acceptance of stress management is clearly a bona fide result of the Company A MRM training. Stress management is also the single most effective change when training effects on subsequent safety performance are examined. Stress management is a topic the training program emphasizes and those respondent attitudes show that it "takes." Although few Company A AMT respondents specifically state that they will subsequently apply the lessons learned about stress management (Figure 5), many do report acting more carefully and self-consciously in the months following training (Figure 6).

Stress management is an activity that maintenance personnel can do by themselves and which does not require the involvement of others (although cooperation may benefit all parties in this regard). The training helps Company A AMTs and their Leads improve their individual approach. As it does so that improvement appears also to lead to improved safety. But this continued emphasis on working alone may be placing AMTs in the position of not knowing whether or how much the MRM program is working, or whether other people actually value the lessons of the training as they did. This uncertainty may lead to frustration.

Frustration and Aggression in Long Term Response to MRM

The six month increase in the Co.A AMT value of assertiveness and the coincident decreases in respondents' views of safety awareness and goal sharing (Figure 3) may be part of the same reaction: in a work unit where safety practices and goal sharing aren't seen to improve, (or aren't seen to be serving safety issues), AMTs may come to value speaking out (or acting out) as the one thing they can do as individuals to draw attention to the (perceived) slow progress of the MRM program. This is also consistent with the drop in enthusiasm and optimism and the increase in negative comments in the six month survey (Figure 1).

The Absence of Maintenance Management in MRM and Its Possible Effects

This emphasis on specially created MRM training for AMTs, and only for AMTs, may have some built-in features that lead to the frustration described above. Although that trend is well intentioned -- and for many purposes, highly successful -- obstacles and pitfalls remain for the unwary. Particular problems include an over-emphasis on training AMTs and allowing a resulting under-emphasis on sustaining change and fostering improvements with the newfound communication skills and safety attitudes to occur. This Company A experience with AMT MRM training seems to illustrate this effect.

A single episode, or an ongoing process?

Sometimes the new MRM training is intended as a "one-time-only" session. There is increasing awareness that a one-shot training program is not enough. Indeed MRM is the beginning of a cultural change in maintenance. Sometimes the decision for follow-on training is made only after the initial session has been completed for all intended recipients. In other cases the continuous process of culture change is recognized in advance. That recognition may offset the possible frustration described above. Company D's planned MRM program variation reflects this. It is reported to start with one day of MRM training for a cross-section of all maintenance personnel, followed by a pre-planned day of recurrent training a few months later. That variation deserves study as it is implemented.

Conclusions

The data in the preceding report establish the positive effects of MRM training. These initial results must be further examined and confirmed, but they do corroborate earlier findings and current predictions.

Participants in the MRM programs in Companies A and B and C all showed substantial enthusiasm about their training (Figure 1). This effect has been noted in past research into maintenance resource management training and the effect is well documented.

Some Specific Positive Effects

Engineers' attitudes improve

The Company A Engineering MRM program was designed to change attitudes toward the hazards of stress and pressure; and to provide encouragement to speak up assertively when safety might be compromised. The engineers post-training feeling and attitudes confirm that they felt substantially more positive about all four MRM-related topics "assertiveness," "stress management," "participation," and "teamwork" (Figure 2).

AMT's attitudes improve immediately after training

AMTs also report favorable changes in attitude toward participation, teamwork and stress management. Because the training program for AMTs in Companies A, B and C was not intended to emphasize assertiveness, that attitude is not expected to change much as a result of the training in any of those sites. The data in the present report help illustrate that.

Attitudes remain high in the months following training

Follow-up surveys for the Company A AMTs confirm that the three MRM-related attitudes of "participation," "teamwork," and "stress management," tend to stay at their improved post-training levels.

Some anticipated behavior is achieved in months following training (but some is not)

Immediately after the training, many of the Company A AMTs said they expected to be more aware of their own behavior, to work more carefully and fight complacency, to be safety conscious. Many also said they would interact more with others. In the months following most reported that indeed they had been more aware of themselves and of safety, but few reported more or better communication with others. Few also reported improvements in managing stress.

Expected safety performance improves following training

In the 18 months following the onset of MRM training for Company A line maintenance personnel, both occupational injury and aircraft ground damage performance improved in line maintenance stations. For base maintenance, where the MRM program has less than one year's experience, the results are suggestive, but not conclusive.

Improved attitudes after MRM training are related to improved safety

Positive attitudes toward stress management 2 months after training showed the strongest correlations with low rates of injury and aircraft damage.

Some Potential Pitfalls

Raising the participants' expectations for MRM may be a problem

Despite the many positive results above, continued enthusiasm for the program seems problematic to maintain. The slide in reported usefulness of the training and the increased frequency of negative comments about how the training is applied are growing trends in Company A's AMTs two month and six month surveys. This decline in enthusiasm may be associated with the declining opinions about group goal attainment noted above. Despite positive trends apparent in Company A's program, there may not be enough continued action or support for MRM. Additionally the positive effects of Company A's program, reported here, have not been widely available for diffusion to that company's participants. Increased involvement of the training's past participants in survey feedback and in ongoing safety initiatives and continued attempts to improve communication may counter the negative backlash observed here.

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APPENDIX A

Date_____

(Revised 12/17/97)

MAINTENANCE RESOURCE MANAGEMENT

TECHNICAL OPERATIONS QUESTIONNAIRE (MRM/TOQ)

"Two-Month Follow-up" Survey

Please answer by writing beside each item the number that best reflects your personal opinion.

****SCALE****

1	2	3	4	5
Disagree Strongly	**Disagree Slightly**	**Neutral**	**Agree Slightly**	**Agree Strongly**

_____ 1. Maintenance team members should avoid disagreeing with others.

_____ 2. It is important to avoid negative comments about the procedures and techniques of other team members.

_____ 3. I am encouraged by my supervisor and co-workers to report any un-safe conditions I may observe.

_____ 4. Leads will not compromise safety for profitability.

_____ 5. We should be aware of and sensitive to the personal and work-related problems of other Maintenance team members.

_____ 6. The manager, supervisor, or lead in charge should take hands-on control and make all decisions in emergency and non-standard situations.

_____ 7. I know the proper channels to route questions regarding safety practices.

_____ 8. Maintenance team members should not question the decisions or actions of the manager, supervisor, or leads except when they threaten the safety of the operation.

_____ 9. Even when fatigued, I perform effectively during critical phases of work.

****SCALE****

1	2	3	4	5
Disagree Strongly	**Disagree Slightly**	**Neutral**	**Agree Slightly**	**Agree Strongly**

_____10. My suggestions about safety would be acted upon if I expressed them to my supervisor.

_____11. There are no circumstances where the subordinate employee should assume control of a project.

_____12. A debriefing and critique of procedures and decisions after the completion of each major task is an important part of developing and maintaining effective team coordination.

_____13. Overall, successful Maintenance management is primarily a result of the leader’s technical proficiency.

_____14. Training is one of management's most important responsibilities.

_____15. Start-of-the-shift team meetings are important for safety and for effective team management.

_____16. Effective team coordination requires each person to take into account the personalities of other team members.

_____17. A truly professional Maintenance team member, manager, supervisor, or lead can leave personal problems behind.

_____18. My decision-making ability is as good in abnormal situations as in routine daily operations.

_____19. Supervisors will not compromise safety for profitability.

PLEASE GO ON TO THE NEXT PAGE

****SCALE****

1	2	3	4	5
Disagree Strongly	**Disagree Slightly**	**Neutral**	**Agree Slightly**	**Agree Strongly**

In the following, "my work group" refers to those people who report to the same manager or supervisor that I do.

_____20. I am kept informed by others in my work group about the goals and objectives of this organization. (e.g., safety, quality, service, etc.)

_____21. Work goals and priorities are understood and agreed to by members of my group.

_____22. Employees in my work group receive detailed feedback regarding the organization's performance.

_____23. If employees in my work group disagree with the goals and priorities that have been established, they feel free to raise their concerns with supervision.

_____24. Employees in other groups within Maintenance plan and coordinate their activities effectively together with people in my work group.

_____25. Employees in other groups, departments and divisions throughout the company act as if they share many of the same organizational goals that we do.

ABOUT THE HUMAN FACTORS TRAINING YOU RECENTLY RECEIVED

_____26. The Human Factors training in Maintenance has increased aviation safety and teamwork effectiveness.

_____27 The Human Factors training has been useful to others.

28. How much has the Human Factors training changed your behavior on the job? (circle one from list below.)

No Change **A Slight Change** **A Moderate Change** **A Large Change**

29. What changes have you made as a result of the Human Factors Training?

_____

_____

_____

30. How will you further use the Human Factors training in the coming months?

_____

_____

_____

31. Looking back on it now, what aspects of the training were particularly good?

_____

_____

_____

PLEASE GO ON TO THE NEXT PAGE

BACKGROUND INFORMATION

JOB TITLE: _____

YEARS IN PRESENT POSITION with [COMPANY]: _____

TOTAL YEARS with [COMPANY]: _____

DEPARTMENT YOU WORK IN: _____

YOUR CITY NAME OR CODE: _____

SHIFT: _____

PAST EXPERIENCE or TRAINING (# OF YEARS: fill in below)

_____ MILITARY

_____ TRADE SCHOOL

_____ COLLEGE

_____ OTHER AIRLINE

(Specify _____)

YEAR of BIRTH: 19_____

MALE (**M**) or FEMALE (**F**): _____

This completes the questionnaire

Thank you for your participation

APPENDIX B (DEMOGRAPHIC DATA: ALL SURVEYS COMPARED)

	Co.D Baseline (n=399)	Co.A EngrPre (n=88)	Co.A EngrPost (n=108)	Co.A AMT Pre-trng (n =3,495)	Co.A AMT Post-trng (n=3,280)
Mean Age	44.3	35.2	35.4	40.6	40.6
Yrs in Mx	12.5	6.4	6.5	13.7	13.6
JOB TITLE					
%Mechanics	59.3			76	76.9
%Inspectors	5.2			2	2.4
%Asst Sups	1.6			8	8
%Foremen	6.6			0.5	0.1
%Engineers	0.8	51.8	50.5		
%EngrSplst		16.5	16.5		
%Instructors	0.3				
%Mgt	4.1		1		0.3
TOTAL	77.9	68.3	68	86.5	87.7
	Co.D Baseline (n=399)	**Co.A EngrPre (n=88)**	**Co.A EngrPost (n=108)**	**Co.A AMT Pre-trng (n =3,495)**	**Co.A AMT Post-trng (n=3,280)**
Day shift	39.2	92.6	93.2	41	42

Afternoon	24.9	7.4	3.4	30	27
Nights	26.2		2.3	25	28
Tot shift	90.3	100	98.9	96	97
DEPART.	**Co.D Baseline (n=399)**	**Co.A EngrPre (n=88)**	**Co.A EngrPost (n=108)**	**Co.A AMT Pre-trng (n =3,495)**	**Co.A AMT Post-trng (n=3,280)**
%Line	23.8			54.5	54.4
%Base	22.2			34.7	35
%QC	3.3			2.3	2.4
%MatlSvs	5			7.7	7.7
%Engr	2	100	100	0	0
%Planning					
%Shops	18.3	0	0	0	0
TOTAL	74.6	100	100	99.2	99.5

Appendix B continued (Demographic Data: All Surveys Compared)

	Co.A AMT 2MoFollow-up (n=556)	**Co.A AMT 6MoFollow-up (n= 254)**	**Co.A 2moSurvey (n=147)**	**Co.A 6moSurvey (n=154)**	**Co.B 6mo (n=44)**	**Co.C 12mo (n=21)**
Mean Age	41.4	44.3	45.9	45.6	42.2	37.3
Yrs in Mx	13.9	16.9	19.8	21.4	17.6	14.9
JOB TITLE						
%Mechanics	69.8	71.6	77.8	65.7	40.5	55
%Inspectors	2.3	3.1	3	6	11.9	15

%Asst Sups	13	14.7	11.1	9	14.3	11
%Foremen	0.5	1.3	1.5	2.2	0	10
%Engineers		0.4				
%EngrSplst						
%Instructors		2.2	1.5	9		
%Mgt	0.9	0.4	0	1.5	11.9	9
TOTAL	86.5	93.7	94.9	93.4	78.6	100
	Co.A AMT 2MoFollow-up (n=556)	**Co.A AMT 6MoFollow-up (n= 254)**	**Co.A 2moSurvey (n=147)**	**Co.A 6moSurvey (n=154)**	**Co.B 6mo (n=44)**	**Co.C 12mo (n=21)**
Day shift	42.8	50.9	46.6	59.8	61.5	61.9
Afternoon	27.1	16.1	20.6	19.7	7.7	14.3
Nights	26.9	30.7	32.1	15.7	5.1	14.3
Tot shift	96.8	97.7	99.3	95.2	74.3	90.5
DEPART.	**Co.A AMT 2MoFollow-up (n=556)**	**Co.A AMT 6MoFollow-up (n= 254)**	**Co.A 2moSurvey (n=147)**	**Co.A 6moSurvey (n=154)**	**Co.B 6moSurvey (n=44)**	**Co.C 12mo (n=21)**
%Line	37.5	69.3	90.2	91.7	73.8	77.3
%Base	50.7	12.4	4.5	1.7	0	9.1
%QC	2.2	4.6	3	6.6	19	9.1
%MatlSvs	9	1.4	1		2.4	0
%Engr	0	0.5			0	0
%Planning		0.5			4.8	4.5

%Shops	0				0	0
TOTAL	99.4	88.7	98.7	100	100	100

APPENDIX C (INTERCORRELATION DATA: ALL SITES COMPARED)

Five Program Site Samples

The cell entries the the five tables below are Spearman Rank Order Correlation coefficients ("rho"), or Pearson Product-Moment coefficients ("r") as appropriate. Cell entries in *italics* are statistically significant at the two-tailed .05 confidence level or higher. **Boldface** coefficients are those above r=.40, representing unusually high correlations, -- those which account for more than 15% of the joint variance of the two correlated scales.

Co.A AMT Sample (df>3,200) .p.05<.15, 2-tailed

Post-trng Intercorrelations	1	2	3	4	5	6
1.Communication & Teamwork	--	-.08	.01	-.06	*.29*	*.33*
2.Share Command Responsibility		--	*.30*	*.38*	*-.27*	*-.20*
3.Stress Management			--	*.17*	*-.16*	-.10
4.Assertiveness				--	*-.20*	*-.17*
5.Goal Sharing					--	**.57**
6.Safety Awareness						--

Co.A Engineering Sample (df=106) p.05<.20, 2-tailed

Post-trng Intercorrelations	1	2	3	4	5	6
1.Communication & Teamwork	--	-.15	.02	*-.24*	*.29*	*.26*

2.Share Command Responsibility		--	*.24*	*.32*	-.17	-.02
3.Stress Management			--	*.26*	-.13	-.18
4.Assertiveness				--	-*.23*	-*.23*
5.Goal Sharing					--	**.41**
6.Safety Awareness						--

Co.D Baseline (df=386) p.05<.11, 2-tailed

Intercorrelations	1	2	3	4	5	6
1.Communication & Teamwork	--	-.03	-.07	-*.13*	*.18*	*.16*
2.Share Command Responsibility		--	**.***25*	*.19*	-*.11*	-.07
3.Stress Management			--	.05	-*.12*	-*.11*
4.Assertiveness				--	-*.17*	-*.17*
5.Goal Sharing					--	**.53**
6.Safety Awareness						--

Appendix C continued (Intercorrelation data: All Sites Compared)

Co.B (df=43) p.05<.29, 2-tailed

6mo Survey Intercorrelations	1	2	3	4	5	6
1.Communication & Teamwork	--	-.07	.12	-.16	.22	*.30*
2.Share Command Responsibility		--	.25	.16	-.16	-.14
3.Stress Management			--	.01	-.21	-.26

4.Assertiveness				--	-.03	-.15
5.Goal Sharing					--	**.45**
6.Safety Awareness						--

Co.C (df=20) p.05<.42, 2-tailed

12mo Survey Intercorrelations	1	2	3	4	5	6
1.Communication & Teamwork	--	-.41	-.10	-.**46**	**.52**	.**50**
2.Share Command Responsibility		--	.38	.27	-.38	-.37
3.Stress Management			--	-.22	.07	.04
4.Assertiveness				--	-.27	-.16
5.Goal Sharing					--	.33
6.Safety Awareness						--